Classifying The Aptitude of Civil Engineering Project Managers (CEPM) Using Multivariate Discriminant Analysis (MDA)

by

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(Ph.D)

Loughborough University

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ABSTRACT

Civil Engineering Project Managers (CEPMs) plan, direct and coordinate a wide variety of construction projects, including buildings of all types of residential, commercial, and industrial structures, roads, bridges, wastewater treatment plants, schools and hospitals. CEPMs may supervise a whole civil engineering project or just part of a project and although CEPMs usually play no direct role in the actual construction of a structure, they typically schedule and coordinate all design and construction processes, including the selection, hiring and oversight of specialty trade contractors. CEPMs therefore, supervise the construction process from the conceptual development stage through to final construction whilst simultaneously meeting time, quality, economic, environmental and health and safety performance criteria as defined by the client. CEPMs evaluate and help determine appropriate construction delivery systems and the most cost-effective plan and schedule for completing the project. They divide all required construction site activities into logical steps, budgeting the time required to meet established deadline.

Based upon the massive duties and responsibilities that CEPMs characteristically undertake before and throughout the whole construction cycle, this research has taken place. The predominant aim of this research is to develop a new mathematical model that can be used for classifying the aptitude (capability) of the Civil Engineering Project Manager (CEPM). Although various types of multi-variate analysis were considered, the technique known as Multivariate Discriminate Analysis (MDA) was used. This thesis reported that it can be hypothesised that 5 variables are the best predictor variables to classifying the CEPMs aptitude. These variables are B*v*4 (Team-based bonus for timely project completion); ET*v*2 (specific vocational background); ET*v*3 (practical building knowledge and experience); PL*v*2 (recognition of the interdependence of the project activities) and WS*v*5 (An ability to ensure the health, safety and welfare of others on site). Findings revealed that the Education and Training Factor (ET*v*) had the highest weighting of the seven factors with 16.61%. This was followed by Planning Factor (16.00%); Quality Control Factors (14.95%); Management Factor (14.58%); Motivational Factor (13.53%); Personal Factor (13.31%); and Work Situational Factor (10.98%).

The model performance showed that CEPMs were classified accurately by the model at an overall accuracy of 84.8 percent. Poor CEPMs were classified at 82.6 percent accuracy. The average CEPM's were classified at 87.6 percent accuracy and good CEPMs classified at 85.7 percent accuracy.

Quantitative and qualitative approaches were carried out in order to determine the validity of the research findings. Within the first approach (quantitative approach), two validation procedures were investigated. The first approach was the utilisation of a procedure wherein statistical methods were used to derive values to measure the validity of the developed model using the 25% percent hold-out sample data. 25% percent results were then compared with the results obtained from the 75% percent sample. The second quantitative validation approach used a one-sample t-test procedure to test whether there was any difference between means of the actual and predicted classification values obtained from the 25% percent hold-out sample models. Because results for both (75% and 25%) samples are highly similar, it could be concluded that models developed were valid. The results from the second approach showed that at the 95% percent confidence interval, the p-value (sig. e tailed) associated with the t-statistics values in each of the classification models showed that there in no significant difference between the predicted and actual groups classification. Finally, a qualitative approach to validation was undertaken using the collective comments and feedback of participating construction and civil engineering professionals. The feedback and comments were generally positive and there was a general consensus that the findings were robust.

Key words:
Multivariate Discriminate Analysis (MDA), Civil Engineering Project Manager's (CEPM) responsibilities, Civil Engineering Project, Statistical Techniques, Factor and Variables Impact on CEPM.

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More than three years have passed since I started the work for my thesis (PhD investigation). This thesis work has given me a greater understanding of the importance of performing proper research as well as a deeper understanding of the importance of civil engineering project managers aptitude within the construction and civil engineering industries. This knowledge will hopefully help others in their future research and hopefully my own career in years ahead.

There are some people who helped and supported me along the way and to whom I feel eternally grateful

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CHAPTER _1_
Introduction

1.0 INTRODUCTION

In today's increasingly competitive and dynamic business environment, the rapid, accurate and cost effective implementation of projects becomes of paramount importance to organizations striving for success (Czuchry *et al.*, 2003; Wideman *et al.*, 1989; and Rounds *et al.*, 1985). Wherever the projects are involved with marketing, new product development, information technology, finance, human resources or operations, project management will provide the right concepts, methods and tools to ensure the success of the initiatives undertaken (Hicks *et al.*, 1996; Wideman *et al.*, 2000; Svensson *et al.*, 2003., and Scutt *et al.*, 2004).

Project management is the professional discipline which separates the management function of a project from the design and execution functions (Barrie *et al.*, 1984 and Abdul-aziz *et al.*, 2002). Management and design may still be combined on smaller projects and be preformed by the leader of the design team. For large or more complex projects the need for separate management has resulted in the evolution of the project management discipline (Czuchry *et al.*, 2003 and Bennett *et al.*, 1991). Indeed, project management has a long history but in its modern form its use within the construction industry only extends back for as little as 30-40 years (Halpin *et al.*, 1980).

Much of earlier codification of the principles and practices of project management was developed in the United States, although the Chartered Institute of Building (CIOP) published its seminal work on the subject in 1979 (Wideman *et al.*, 2000). Project management may be defined as the overall planning, co-ordination and control of the project from inception to completion and aims to meet a client's requirements in order to produce a functionally (and financially) viable project that will be completed on time, within authorised cost, to the required quality standards, (Battikha *et al.*, 2003). In other words, project management is an evolutionary stage (Barber *et al.*, 1992). Although definition of project management and the activities of project managers are not yet precisely agreed there is also no exact project management procedure that is universally adopted by all project managers (Bourne *et al.*, 2004).

Once called the accidental profession, Construction Project Management has emerged as a distinct management discipline (Battikha *et al.*, 2003). Increasingly, government and private companies are turning to project management approaches to encourage innovation, improve efficiency, solve problems and manage scarce resources (Oxley *et al.*, 1996). Traditionally, the architect has been the client's representative and building team leader, however, with growing client discontent, new forms of building procurements have emerged to holistically address client concern an industry caricaturised by a high degree of complexity. At present, architects, builders, engineers and quantity surveyors, all with varying degree of success, can be employed as a Civil Engineering Project Managers (CEPM) (Cheng *et al.*, 1994). Project management is founded upon the need to develop a framework which will control quality, time, cost safely and environmental parameters as dictated by clients and in so doing, provide communication, co-ordination and control capabilities with which to increase the efficiency of the construction process (Clarke *et al.* 1998).

Over the last 40 years the need to develop innovative management activities and techniques to cope with the increasingly complex administrative and technological environment in which construction contractors have to operate within is apparent (Bossink *et al.*, 2002). Some researchers have also criticised the construction industry's failure to respond to these challenges (Fillis *et al.*, 2004). The creation of CEPM position would appear to be a response to this situation and in many instances this position has evolved to become a fully fledged external project management organisation that exists as an annex to conventional construction organisations and other parties to the contract. In both cases, the objective has been to distil the management functions associated with projects, and the vast responsibility for them into a separately identified unit (Barrie *et al.*, 1984 and Battikha *et al.*, 2003).

During pre, contract and post contract phases of a construction project, management is exercised at various levels; it is important to recognise at this juncture that project management is the management and control of the contributors to the project and its sole objective is the satisfactory completion of a project on behalf of the client (Blakeman *et al.*, 1995). The contractor will still manage the construction process, the consultants will still manage their contributions. Individuals working on the project will still manage their own work but project management will co-ordinate and manage the efforts of all parties concerned with the project at an holistic level (Bossink *et al.*, 2002).

1.1 THE CONSTRUCTION PROJECT

A project is a group of activities undertaken to meet one or more specific objectives (Bourne *et al.*, 2004). These objectives could include: solving a problem; building or upgrading a system or product; launching a product or service; implementing a strategic plan; changing a process; or one of many other unique efforts (Czuchry *et al.*, 2003). Projects can differ in size from small and simple to large and complex (Czuchry *et al.*, 2003). However, construction projects are temporary and have specific starting and completion dates (Gale *et al.*, 1995).

To ensure a project's success, a clear and accurate definition of a project must be prepared and this is of critical importance because the clearer the target, the more likely the project team will meet it (Hicks *et al.*, 1996). Defining a project is a process of selection and reduction of the ideas and perspectives of those involved into a set of clearly defined objectives, key success criteria (sometimes called Key Performance Indicators or simply KPIs) and evaluated risks (Day *et al.*, 2004). The definition process should culminate in the production of a project definition document, otherwise known as a project charter (Gidado *et al.*, 1992). The project definition document should be approved and issued by a CEPM with the authority to apply organisational resources to the project activities (Groth *et al.*, 1997). Therefore, the CEPM (or the construction management team) will have detailed knowledge of the size, cost and business value of the project (Koushki *et al.*, 2004).

1.2 DEFINITION OF PROJECT MANAGEMENT

The management of construction projects requires knowledge of modern management as well as an in-depth understanding of the design and construction process (Battikha *et al.*, 2003). Construction projects have a specific set of objectives and constraints such as a required time frame for completion (Harris *et al.,* 2000 and Project Management Institute 2000). While the relevant technology, institutional arrangements or processes will differ, the management of such projects has much in common with the management of similar types of projects in other specialty or technology domains such as aerospace, pharmaceutical and energy developments.

Generally, construction project management is distinguished from the general management of corporations by the mission-oriental nature of a project (MacNeil *et al.*, 2004) whereby a project organisation will generally be terminated when the mission is accomplished (Kanoglu *et al.*, 2003). According to the project management institute, the discipline of project management can be defined as follows:

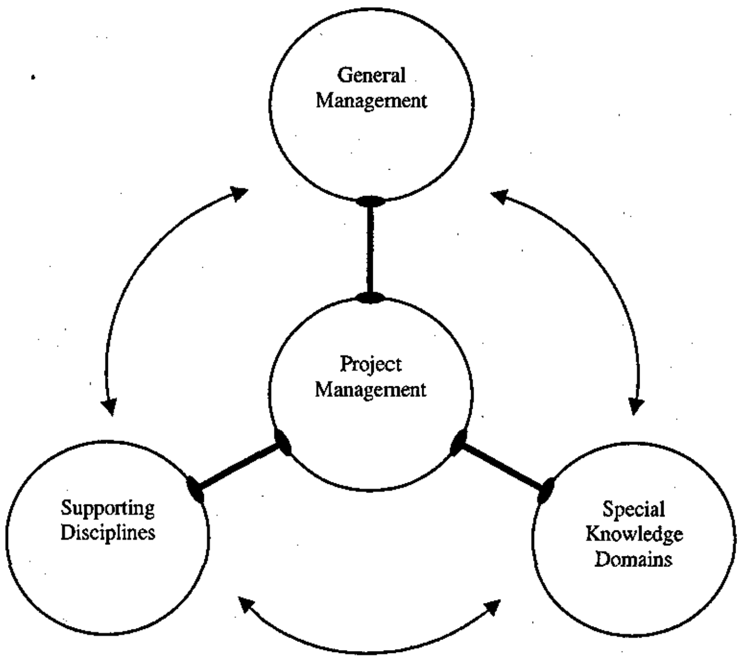
"project management is a methodical approach to planning and guiding project processes from start to finish. Also, the processes are guided through five stages: initiation, planning, executing, controlling, and closing. Project management can be applied to almost any type of project and is widely used to control the complex processes of software development projects."

The definition of *Project Management*, is the application of knowledge, skills, tools and techniques to describe, organise, oversee and control the various project processes (Barrie *et al.*, 1984, Battikha *et al.*, 2003). In other words, project management is the art of directing and coordinating human and materials resources throughout the life of a project by using modern management techniques to achieve predetermined objectives of scope, cost, time, quality and participation satisfaction (Wideman *et al.*, 1986).

By contrast, the general management of business and industrial corporations assumes a broader outlook with greater continuity of operations (Knoepfel *et al.*, 1989). Nevertheless, there are sufficient similarities as well as differences between the two so that modern management techniques developed for general management may be adapted for construction project management (Ngai *et al.*, 1997).

The basic ingredients for a project management framework may be represented schematically in Figure 1.1 (Stuckenbruck *et al.*, 1986). A working knowledge of general management and similarity with the special knowledge domain related to the project are indispensable (Hodgetts *et al.*, 1979 and Koushki *et al.*, 2004). Supporting disciplines such as computer and decision sciences may also play an important role (Phua *et al.*, 2004). In fact, modern management practices and various special knowledge domains have absorbed various techniques or tools which were once identified only with the supporting disciplines. For example, computer-based information and decision support systems are now common-place tools for general construction management (Holland *et al.*, 2004 and Osterberg *et al.*, 2004). Similarly, various operations research techniques such as linear programming and network analysis are now widely used in many knowledge or application domains (Day *et al.*, 2004). Hence, the representation in Figure 1.1 reflects only the sources from which the project management framework evolves.

Figure 1.1 Basic Ingredients in Project Management.



Project management in construction encompasses a set of objectives which may be accomplished by implementing a series of operations subject to resource constraints (Ahmed *et al.*, 1998). There are potential conflicts between the stated objectives with regard to scope, (cost, time, safety, the environmental and quality) and the constraints imposed by labour, material and financial resources (Blismas *et al.*, 2004). These conflicts should be resolved at the onset of a project by making the necessary tradeoffs or creating new alternatives (Fernie *et al.*, 2003). Subsequently, the functions of project management for construction generally includes the following:

i. Specification of project objectives and plans including delineation of scope, budgeting, scheduling, setting performance requirements and selecting project participants.
ii. Maximisation of efficient resource utilisation through procurement of labour, materials and equipment according to the prescribed schedule and plan.

iii. Implementation of various operations through proper coordination and control of planning, design, estimating, contracting and construction throughout the entire process.

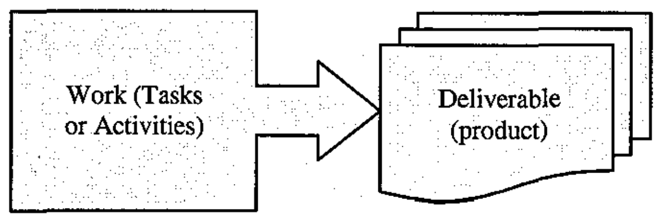
iv. Development of effective communications and mechanisms for resolving conflicts among the various participants.

Finally, successful projects are rarely achieved by themselves (Brown *et al.*, 2003); they must be planned and executed (Carmichael *et al.*, 1995). They must have support at every level of management and from the organisation in general (Bossink *et al.*, 2002). To be successful, projects must also have a responsible and empowered CEPM to drive, direct and monitor the project (Carmichael *et al.*, 1995 and Clarke *et al.*, 1998). Project management is that discipline which employs skills and knowledge to achieve project goals through various project activities (Mustapha *et al.*, 1996). It involves controlling costs, time, risks (e.g financial and safety), project scope and quality though effective project management processes (Hwang *et al.*, 2003).

1.3 PROJECT LIFE CYCLE

Projects have life cycles and are usually performed in phases (Kenneth *et al.*, 1993) with each phase accomplishing specific work packages that when combined reach the project goal and produces one or more deliverables as depicted in Figure 1.2 (Kanoglu *et al.*, 2003). These are tangible deliverables, real items used in attaining the final goal of the project and could include plans, studies, designs software or hardware prototypes. The end of the phase is defined by completing its deliverable.

Figure 1.2 Phases Produce Deliverables.

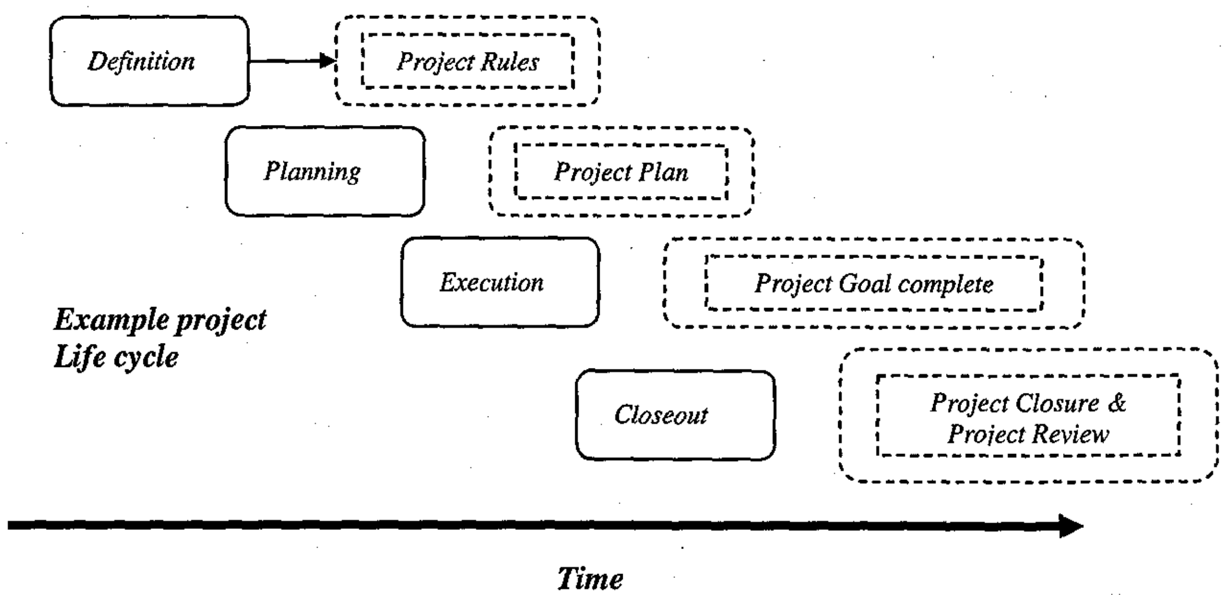


While major aspects of project management are applicable across all projects, life cycles may vary, depending on the type of project and organisation performing the work (Knoepfel *et al.*, 1989). It is important to implement an appropriate life cycle for the product (Albert *et al.*, 1992).

1.4 PROJECT PHASES

The generic phases identified in Figure 1.3 are common across most projects (Kanoglu *et al.*, 2003). However, they may be called by different names or split into additional phases (Gidado *et al.*, 1992). They may even be iterative, where, for example, a prototype is designed, built and tested, then the results are used to design, build and test a new prototype.

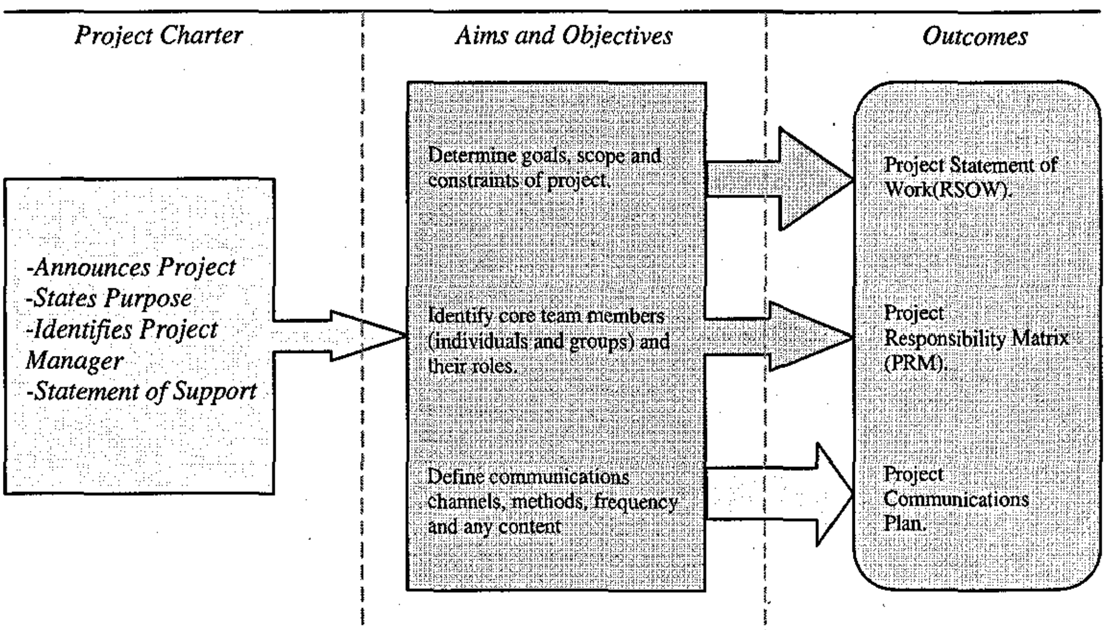
Figure 1.3 Example of Project Life Cycle.



1.4.1 Definition Phase

This phase begins when a project charter is created by upper management that defines the project's purpose and identifies a CEPM (Merna *et al.*, 1990). The charter should also include a statement of support authorising the CEPM (Nguyen *et al.*, 1988) and defining the rules of the project. The CEPM and stakeholders determine the goals, scope and constraints of the project (Kenneth *et al.*, 1993). Key individuals and groups are identified as members of the project core team and their roles are defined by the CEPM and upper management (Page *et al.*, 2002). Communications channels, authority and the chain of command are also defined by upper management with the CEPM. These project rules are written in three documents, namely: the Project Statement of Work (PSOW), the Project Responsibility Matrix (PRM) and Project Communication Plan (PCP). The PSOW establishes the scope of the project and what documents are to be accomplished and for an internal project, the PSOW becomes the primary requirements document. However, the PSOW is not the same as a contract Statement of Work (SOW) (Koch *et al.*, 2003). For a project where much of the work is contracted, the SOW is a binding, contractual agreement. Figure 1.4 depicts the input, major activities and products of the definition phase.

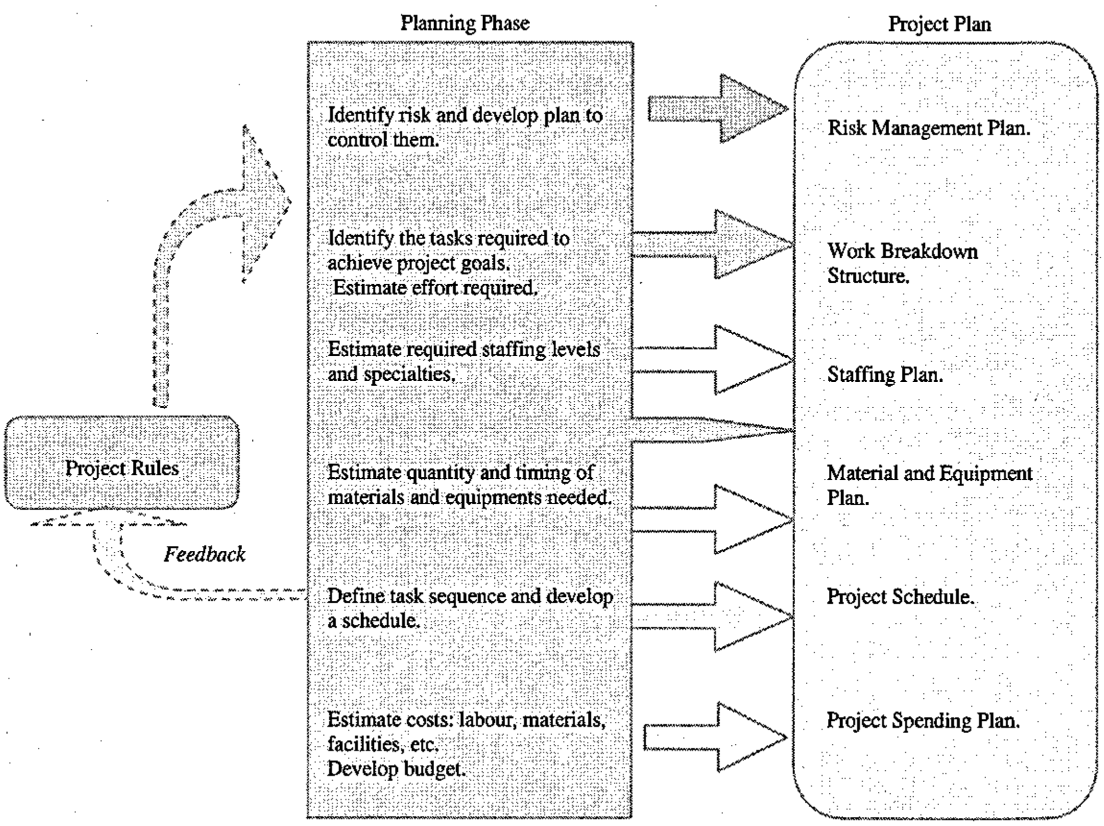
Figure 1.4 Project Definition Phase.



1.4.2 Planning Phase

The planning phase uses the project rules as a foundation upon which to define project goals (Price *et al.*, 2003). It is performed by the CEPM and the core project team, interfacing with appropriate elements of the organisation and identifies the actual work to be completed. It includes estimating time, cost and resources required to perform the work and produces operational plans to serve as a baseline and direct the work (Zozaya *et al.*, 1988). A key part of schedule planning is to identify the *critical path* (Molleman *et al.*, 2003). This is the chain of interdependent, sequential project activities which determines the minimum schedule for the project. Planning also includes risk identification and risk reduction efforts (Ang *et al.*, 1975; Baracco *et al.*, 1987; and Dunlop *et al.*, 2004). Results of the planning phase become the project plan. Figure 1.5 shows the input, activities and products of the planning phase. Note that the feedback loop from the phase activities to the project rules. This indicates that the rules may need to be modified after more detailed analysis in this phase reveal deficiencies or inefficiencies in the rules. This illustrates the iterative nature of project management and the inherent fluidity within the project planning phase of construction works.

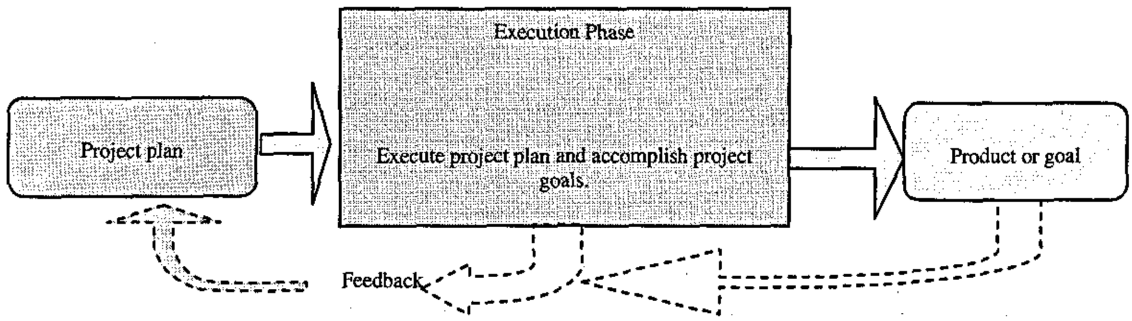
Figure 1.5 Project Planning Phase.



1.4.3 Execution Phase

The execution phase is where the project goals are achieved (Dunlop *et al.*, 2004). While Figure 1.6 may make it look far simpler than the planning phase, the execution phase entails directing the various work groups in their activities, monitoring their progress, solving problems and resolving issues that arise, making changes to the plan and coordinating these changes (Baracco-Miller *et al.*, 1987 and Barber *et al.*, 1992). If the planning has been done well, then the execution phase should run smoothly. This phase is complete when the product is complete or the project goals are reached.

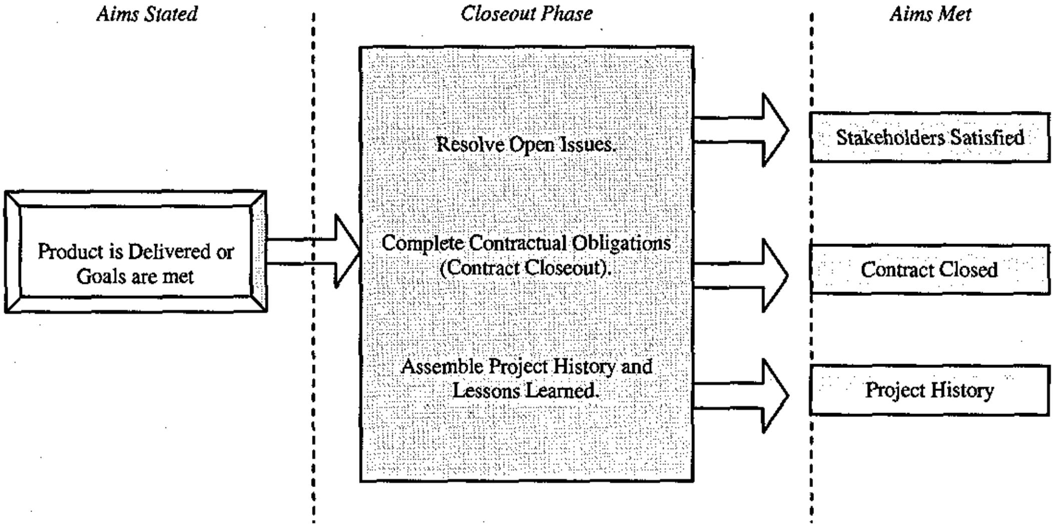
Figure 1.6 Project Execution Phase.



1.4.4 Closeout Phase

The closeout phase begins with the delivery of the product or completion of the project goals. It consists primarily of tying up loose ends (Nguyen *et al.*, 1998). Any unresolved issues from the contract or statement of work are resolved in this phase (Dainty *et al.,* 2004); the contract is signed off as fulfilled and all other paperwork is completed (Hughes *et al.*, 1997). A very important activity of this phase is assembling the project history (Rounds *et al.*, 1985) because this represents a summary of all that has been accomplished (Ngai *et al.*, 1997). It should include information that will allow anybody or the follow-on CEPM to understand how it was done and why. Of particular importance is a compilation of lessons learned from the project so that future projects can be improved upon. Figure 1.7 summarises the closeout phase.

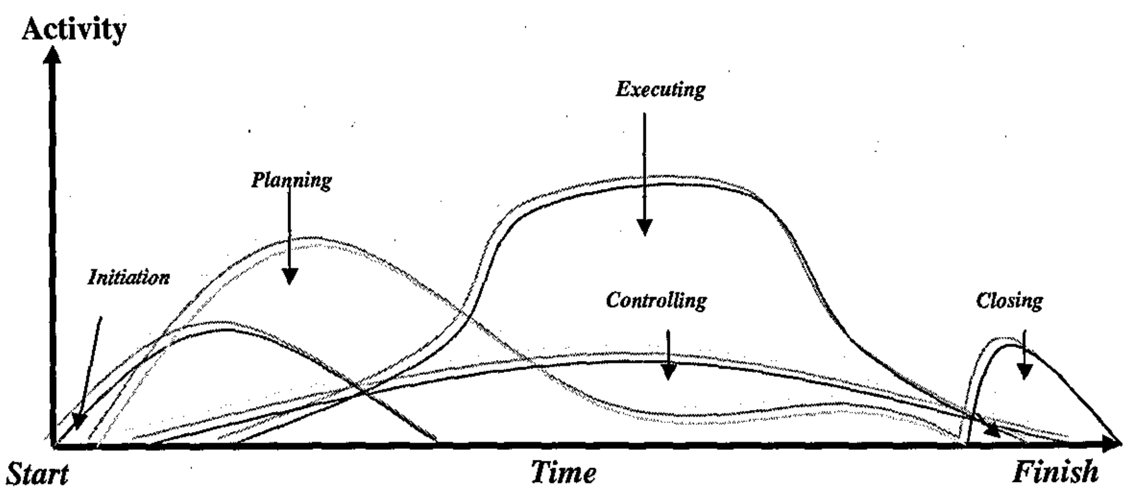
Figure 1.7 Project Closeout Phase.



1.5 PROJECT PROCESSES

Based upon the various definitions referred to earlier in this chapter, five major process groups used in projects have been identified. Processes are sequences of activities that accomplish specific functions necessary to complete some portion of the project (Abdul-Aziz *et al.,* 2002). These are not phases themselves but can be found both in projects and in each of the major phases of a project (Merna *et al.*, 1990). Because the activities in the later phases may require changes in the products of earlier phases, these processes become iterative and often overlap other phases as well as each other. An example of this would be an issue in the execution phase which may require a change to plans made in the planning phase (Bourne *et al.*, 2004). This overlap is shown in Figure 1.8.

Figure 1.8 Project Management Processes Overlap.



Source: (Cornick et al., 1998).

1.6 AIM(S) AND THE OBJECTIVE OF THE INVESTIGATION

Given the huge (and important) task that the CEPM undertakes before, during and after the project cycle life, the aim of this research was to consider the development of a new mathematical classification method that can be used to classify the aptitude of civil engineering project managers (CEPM).

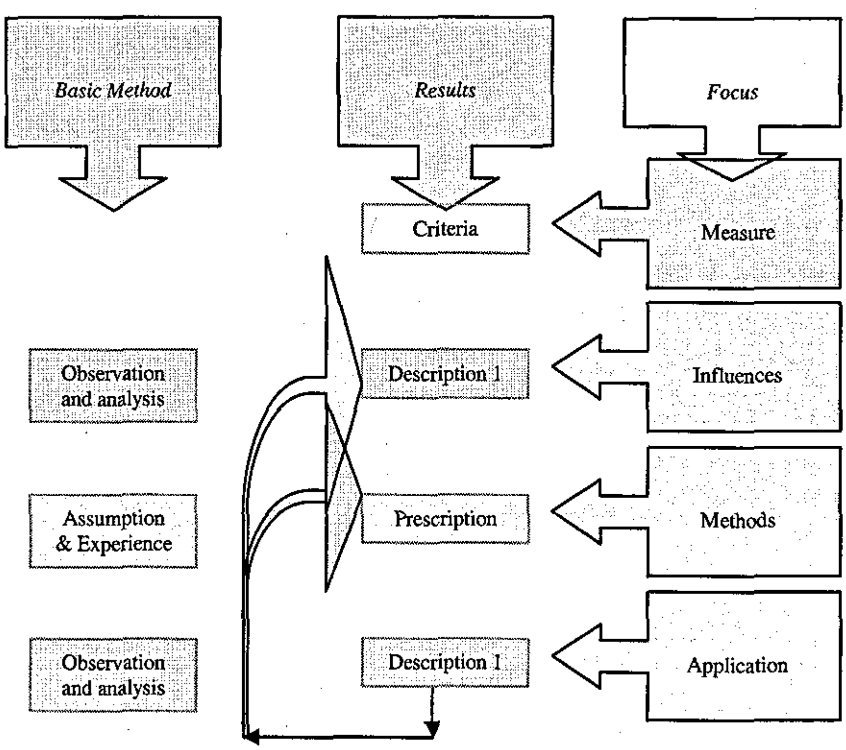
Leading on from these core aims, the main objectives of this research work are:

i. to identifying factors and variables that impact upon a manager's aptitude;
ii. to develop questionnaires that will be used in the survey analysis for collecting the opinions of practitioners to determine whether factors and variables in i) above are applicable in a CEPM context;
iii. to develop a new mathematical model "as new formula" to help construction and civil engineering companies to match the right CEPM to the right civil and construction project; and
iv. to use factors and variables that are shown to be significant classifiers of CEPM aptitude as to improve the capability of existing CEPM staff.

1.7 THE GENERAL PROCESS OF RESEARCH METHODOLOGY

The general design of the methodology adopted for the research consisted of a descriptive study methodology (Prasad *et al.*, 1997) which includes stages of description, followed by prescription with a second descriptive study used to validate the results of the prescription and description. Figure 1.9 provides a schematic diagrammatic representation of the research methodology design.

Figure 1.9 Design Research Methodology.



Source: (Blessing et al., 1998)

In the past researchers have stated that the output from any research work is only as good as the methodology employed (Holt *et al.*, 1998).

1.8 STRUCTURE OF THE THESIS

The introduction chapter aims to provide background information so as to set the direction, aims and objectives of the thesis. Chapter 2 provides a comprehensive literature review of construction project management in order to better understand this branch of construction science. Chapter 3 explores the roles and duties of the CEPM in order to determine which attributes impact upon a manager's aptitude. Chapter 4 provides a comprehensive review of the type of methods that could be suitable for this research.

In chapter 5 the basic theory behind statistical techniques that have been selected and are explained. The design of survey questionnaires is also discussed and factors and variables that have been included in the questionnaires are reported upon. Chapter 6 provides the profile development of an optimum CEPM and also covers some statistical analysis such as finding the distribution of the data collected. Chapter 6 also discusses important rating for the factors and variables (*IR*), and the rank rating of the factors and variables (*RR*) and Multivariate Discriminate Analysis (MDA). MDA was chosen as the main technique for this research work.

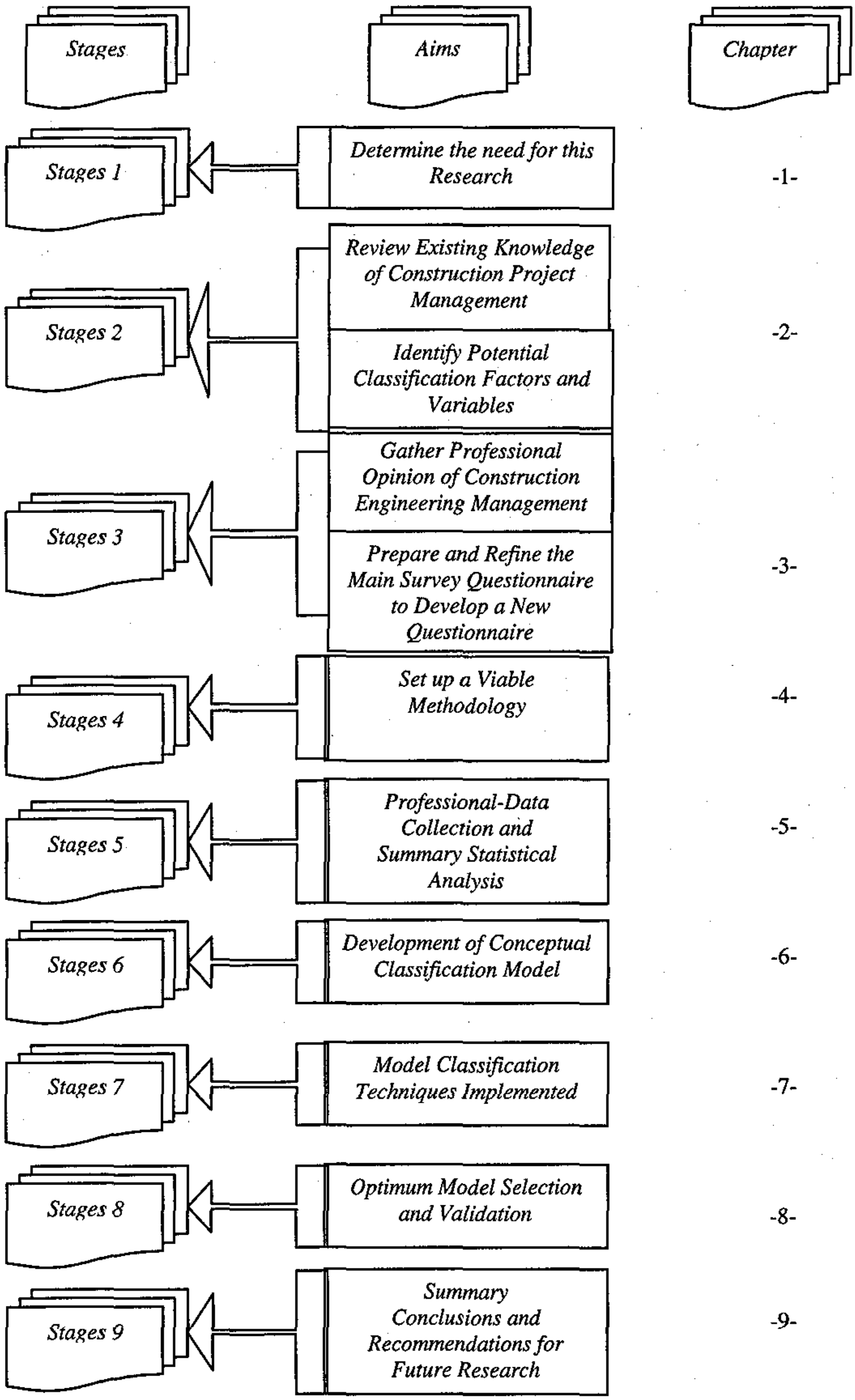
Chapter 7 introduces the Multivariate Discriminate Analysis (MDA) analysis and model development. Chapter 8 provides a detailed description of the CEPM's profile and the analysis which been undertaken on all factors and variables in order to find the Weight Index (*WI*) for each of them. Chapter 9 discusses the classifying procedures implemented and also explains the way of developing the mathematical classification models. Chapter 10 concentrated on the validation of the research findings. Quantitative and qualitative approaches were carried out in order to determine the validity of the research findings. Chapter 11 provides conclusions, recommendations and future research based the findings emanating from this research work.

1.9 SUMMARY

Project management is a carefully planned and organised effort to complete a construction project. Project management includes developing a plan, which includes finding project goals and objectives, specifying tasks or how goals will be achieved, identifying what resources are needed and associating budgets and timelines for completion. It also includes implementing the project plan, along with careful controls to stay on the critical path, that is, to ensure that the plan meets client expectations. Project management usually follows major phases, including feasibility studies, project planning, implementation, evaluation and support/maintenance.

A successful construction project can be adversely affected by improper closeout procedures. To be an effective CEPM, one must be prepared to establish a working structure and a format of proven management principles that support the philosophy of the construction company they serve. A system that will work best for the company has to be designed by the company and then supported from within, to be truly effective. The selection of a CEPM therefore has a major effect on the success of the project. This research has concentrated upon the most important factors and variables that will influence upon the performance that CEPM should have, such as skill, knowledge, and personality or other factors and variables. Figure 1.11 shows the organisation of the thesis.

Figure 1.10 Organisation of Thesis.



CHAPTER _2_
Construction Project Management

2.0 INTRODUCTION

The main purpose of project management is to complete a specified task in an organized way and to have this task delivered on a preset date (Carmichael *et al.*, 1995). Civil Engineering Project Managers (CEPMs) therefore require a high degree of organizational and communicational skills (Cheng *et al.*, 2003 and Bennett *et al.*, 1992). Modern CEPMs today have accumulated a wealth of information on project and programme management science since its inception and first appearance in 1989 (Scutt *et al.*, 2004). Management control is progressive and involves continually making adjustments to the running of a project, after making comparisons between planned and actual results (Wideman *et al.*, 1989 and Rubenstein *et al.*, 2001). The CEPM is also responsible for coordinating and managing labour, materials, equipment, budgets, schedules, contracts and ensuring the safety of employees and the general public (Canter *et al.*, 1993., Carmichael *et al.*, 1995., and Guercini *et al.*, 2004).

Generally, good project management ensures that predefined requirements regarding cost, quality and time safety and environment are met (Willis *et al.*, 1995) but this assumes that clear client requirements are defined at the inception stage of a project (Barber *et al.*, 1992). Based upon these, the CEPM can then manage the activities that lead to successful completion of a project (Blismas *et al.*, 2004) using management techniques relating to planning, organising, coordinating, administrating and controlling. In the context of new build construction and/or refurbishment projects, then the client would achieve most benefit by the early appointment of a CEPM (Bourne *et al.*, 2004). The CEPM should also ideally be involved beyond the opening of the facility, not just to the completion of the building because projects often require maintenance not just the making good of defects (Harris *et al.*, 2000 and (Boyd *et al.*, 2001)).

Generally, construction work under a traditional form of procurement is carried out under a contract that been signed between the client (or the clients representative) and the contractor. The CEPM's function is to ensure that the development meets key performance indictors as defined by the client or the client's representative (Elsby *et al.*, 1981). Given the constantly changing nature of a civil engineering project, CEPMs are continually having to make decisions about methods of operation and the right mix of labour, machines and materials within a working environment (Canter *et al.*, 1993).

At the same time, CEPMs regularly review engineering and architectural drawings and specifications to monitor progress and ensure compliance with plans and schedules (Blenkinsopp *et al.*, 2004). They track and control construction costs against the project budget to avoid cost overruns (Connor *et al.*, 1985). Based upon direct observation and reports by subordinate supervisors, CEPMs may prepare daily reports of progress and requirements for labour, material, machinery and equipment on the construction site (Heraty *et al.*, 1995). They must meet regularly with owners, other constructors, trade contractors, vendors, architects, engineers and others to monitor and coordinate all phases of the construction project (Houlihan *et al.*, 2001).

Although they may hold a variety of job titles, CEPMs plan and direct construction projects (Bossink *et al.*, 2002). They may be owners or salaried employees of a construction management or contracting firm or work under contract or as salaried employee of the owner, developer or management firm overseeing the construction project (Carmichael *et al.*, 1995). They typically schedule and coordinate all design and construction processes including the selection, hiring and supervision of specialty subcontractors (Clarke *et al.*,1998).

On large projects, CEPMs may work for a general contractor, which is the firm with overall responsibility for all activities (Czuchry *et al.*, 2003). They oversee the completion of all construction in accordance with the engineer's or architect's drawings and specifications and prevailing building codes (Lewis *et al.*, 1997). On the other hand, small projects, such as modifying a home, a self-employed CEPM or skilled trades worker who directs and oversees employees is often referred to as the construction contractor.

Large construction projects, such as an office building or industrial complex, are too complicated for one person to manage (Connor *et al.*, 1985 and Dainty *et al.*, 2004). These projects are divided into many segments (Koushki *et al.*, 2004). CEPMs may work as part of a team or be in charge of one or more of these activities (Dulaimi *et al.*, 1999). At the same time, CEPMs evaluate various construction methods and determine the most cost-effective plan and schedule (Slaven *et al.*, 1994). They are responsible for obtaining all necessary permits and licenses and depending upon the contractual arrangements, direct or monitor compliance with building and safety codes and other regulations (Brown *et al.*, 2000). They may have several subordinates, such as assistant managers or superintendents, field engineers, or crew supervisors, reporting to them (Clarke *et al.*, 1998). Hence, an ability to manage others is important.

CEPMs regularly review engineering and architectural drawing and specification to monitor progress and ensure compliance with plans and specifications (Riggs *et al.*, 1988). They track and control construction costs to avoid cost overruns (Schneider *et al.*, 2003). Based upon direct observation and reports by subordinate supervisors, managers may prepare daily reports of progress and requirements for labour, material and machinery and equipment at the construction site. They meet regularly with owners, subcontractors, architects and other design professionals to monitor and coordinate all phases of the construction project (Carmichael *et al.*, 1995).

The most obvious benefit from engaging the CEPM is that of a one-stop-shop in terms of single point responsibility (Bresnen *et al.*, 1986). Single point responsibility can improve communication with the client and in so doing gives, the client greater control and involvement with the project; it can also move more liability onto the CEPM leading to possible savings for the client.

In this chapter, the purpose, benefits and structure of construction project management will be examined. The differences between a manager and civil engineering project managers are then discussed as a precursor to exploring the size and nature of construction projects.

2.1 THE PURPOSE AND BENEFITS OF CONSTRUCTION PROJECT MANAGEMENT

The purpose of project management in the construction industry is to add significant and specific value to the process of delivering construction projects (Wade *et al.*, 2004). This is achieved by the systematic application of a set of generic project-orientated management principles throughout the life of a project (Bourne *et al.*, 2004). Some of these techniques have been tailored to the sector requirements and are unique to the construction industry (Bresnen *et al.*, 1984). In smaller or less complex projects the role may well be combined with other disciplines, e.g. leader of the design team (Pries *et al.*, 1995 and Woodward *et al.*, 1997). Proper project management means excellence in the technical, cost and delivery aspects of the project.

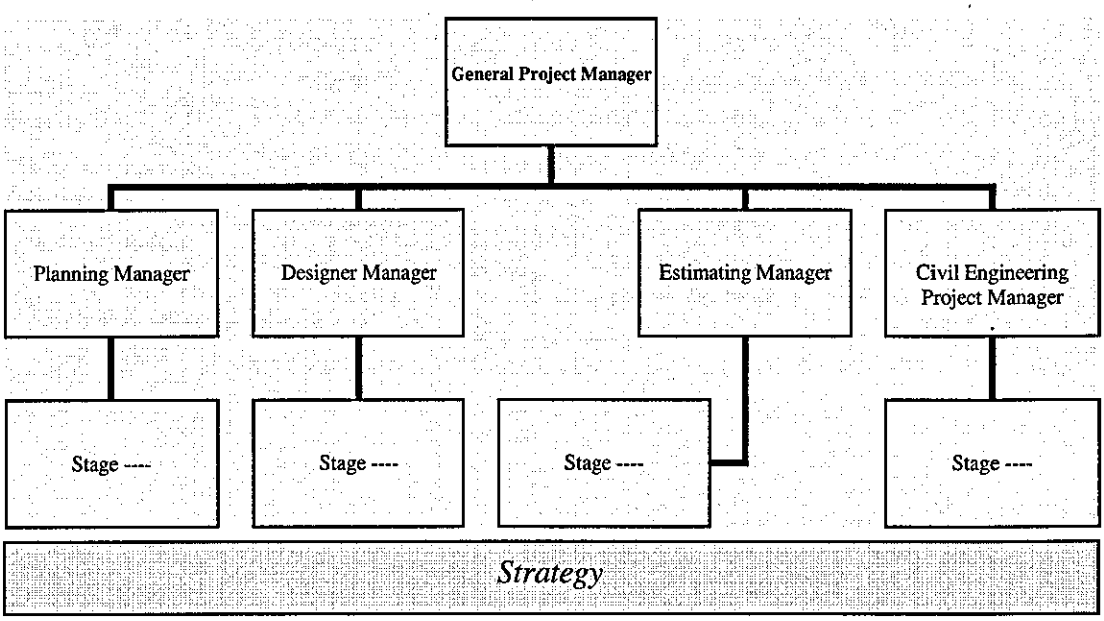
Construction project management is the management of a construction project by someone other than a general contractor (Albert *et al.*, 1992). The construction manager can be the owner or a construction management company (Carmichael *et al.*, 1995). The construction manager is responsible for getting bids, managing and coordinating the various trades necessary for the completion of the construction project (Dulaimi *et al.*, 1999). Construction management is cost effective, as the owner acquires the advantage of competitive bids for each trade separately and pays the construction manager a fee to manage the project (Garvin *et al.*, 1998 and Battikha *et al.*, 2003). The construction manager's fee is fixed, based on the estimate for the total project, therefore giving the construction manager no incentive for extra charges or higher prices for the work being done (Renwich *et al.*, 2003).

2.2 THE STRUCTURE OF PROJECT MANAGEMENT

Construction and development projects involves the co-ordinated actions of many different professionals and specialists to achieve defined objectives (Griffith *et al.*, 2000). The task of project management is to bring the professionals and specialists into the project team at the right time to enable them to make their best possible contribution, efficiently and effectively (Tatum *et al.*, 1987). The professionals and specialists bring knowledge and experience that contribute to decisions, which are embodied in the project information (Kerzner *et al.*, 1984 and Bourne *et al.*, 2004).

The different bodies of knowledge and experience all have the potential to make important contributions to decisions at each and every stage of the project. In construction and development projects there are often far too many professionals and specialists involved for it to be practical. This creates a dilemma because ignoring key bodies of knowledge and experience at any stage may lead to major problems and additional costs for parties to the contract later on in the project (Ahmed *et al.*, 1998). The way to resolve this dilemma is to carefully structure the way the professionals and specialists bring their knowledge and experience into the project team. Figure 2.1 shows the most effective general structure of the project stages (Mills *et al.*, 2001). In many construction projects there is a body of building knowledge and experience in the client organisation.

Figure 2.1 A Project's Teams.



Each stage in the project process is dominated by the broad body of knowledge and experience that is reflected in the stage name. As described in Figure 2.1, essential features of that knowledge and experience need to be taken into account in earlier stages if the best overall outcome is to be achieved (Siemieniuch *et al.*, 2004). The way the professionals and specialists who own that knowledge and experience are brought into the project team at these earlier stages is one issue that needs to be decided upon during the strategy stage (Levitt *et al.*, 1984). The results of each stage influence later stages and it may be necessary to involve the professionals and specialists who undertook earlier stages to explain or review any decisions taken (Day *et al.*, 2004).

Projects usually begin with the inception stage that results from business decisions taken by the client (Moore *et al.*, 1999). Essentially, the inception stage will involve commissioning a CEPM to undertake the next stage, which is to test the feasibility of the project. The feasibility stage is a crucial stage in which a wide variety of professionals and specialists may be required (Moore *et al.*, 2001). It establishes the broad objectives for the project and so exerts an influence throughout subsequent stages.

The next stage is the strategy stage which begins when the CEPM is commissioned to lead the project team to undertake the project (Mustapha *et al.*, 1996). This stage requires the project's objectives, an overall strategy and the selection of key team members to be considered in a highly interactive manner (Koch *et al.*, 2003). It draws on many different bodies of knowledge and experience and crucially, decisions taken at any time may determine the success of the project (Brown *et al.*, 2003). In addition to selecting an overall strategy and key team members to achieve the project's objectives, it determines the overall procurement approach and sets up the control systems that guides the project through to the final post-completion review and project close-out report stages (Brown *et al.*, 2000). In particular, the strategy stage establishes the objectives for the control system which deal with much more than the KPIs relating to quality, time and cost constructs (Carmichael *et al.*, 1995). They provide an agreed means of controlling value from the client's point of view, monitoring financial matters that influence the project's success, managing risk, making decisions, holding meetings, maintaining the project's information systems and many other control systems necessary for the project to be undertaken efficiently (Cheng *et al.*, 1994).

At the completion of the strategy stage, everything is in place for the pre-construction stage when design decisions are made (Price *et al.*, 2003). This stage includes statutory approvals and consents and bringing manufactures, contractors and their supply chains into the project team (Tatum *et al.*, 1987). Similar to earlier stages, the pre-construction stage often requires many different professionals and specialists working in creative and highly interactive ways (Barber *et al.*, 1992). It is therefore important that this stage is carefully managed using the control systems established during the strategy stage to provide everyone involved with relevant, timely and accurate feedback about their decisions (Lacity *et al.*, 1994). Completion of this stage provides all the information needed for construction to begin (Kelley *et al.*, 2002).

The construction stage is when the actual building or other facility that the client needs is produced (Battikha *et al.*, 2003). In modern practice, this is a rapid and efficient assembly process delivering high-quality facilities (Bossink *et al.*, 2002). The process places considerable demands upon the control systems, especially those concerned with time and quality. The complex nature of modern buildings and other facilities and their unique interaction with a specific site means that problems will arise and have to be resolved rapidly (Cheng *et al.*, 1994) (Mills *et al.*, 2001). Information systems are tested to the full, design changes have to be managed, construction and fitting out teams have to be brought into the team and empowered to work efficiently (Dale *et al.*, 1990). Costs have to be controlled and disputes resolved without compromising the value and quality delivered to the client (Koushki *et al.*, 2004) (Phua *et al.*, 2004).

The client's occupational commissioning needs to be managed as carefully as all the other stages because it can have a decisive influence on the project's overall success (Walker *et al.*, 2002) (Rounds *et al.*, 1985). New users need training and help in making best use of their new building or other facility (Bourne *et al.*, 2004). It is good practice for their interest and concerns to be considered during the earlier stages and preparation for their move into the new facility begin early so there are on surprises when the client's organisation moves in (Bittel *et al.*, 1990).

The final stage is the post-completion review and project close-out report stage (Mills *et al.*, 2001). This provides the opportunity for the project team to consider how well the project's objectives have been met and what lessons should be taken from the project (Barber *et al.*, 1992). A formal report describing these matters provides a potentially important contribution to knowledge (Woodward *et al.*, 1997).

2.2.1 General Project Manager

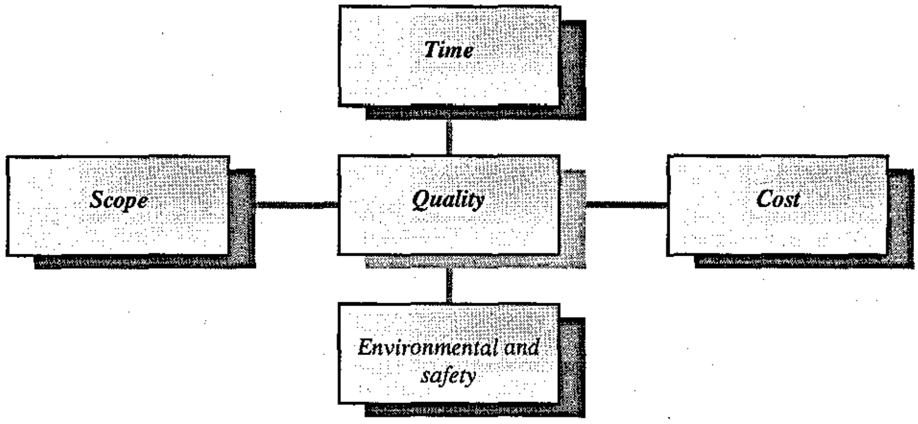
The term manager is not easy to describe because it is commonly used in many different circumstances (Birdir *et al.,* 2002., and Wideman *et al.,* 1989). Any human activity or movements that involves carrying out a non-repetitive task can be project (Mustapha *et al.,* 1996). However, there is a significant difference between carrying out a very simple project (activity) which involves one or two people and one which involves a complex mix of people, organizations and tasks (Torrington *et al.,* 2002, Day *et al.*, 2004 and Blakeman *et al.,* 1995).

Managing projects is one of the oldest and most respected accomplishments known to mankind (Smith *et al.,* 2002). Project management in the modern sense began in the early 1960s, although it has its roots much further back in the latter years of the 19th century (Karaa *et al.,* 1986). The need for project management was driven by businesses that realised the benefit of organising work around projects and the critical need to communicate and co-ordinate work across departments and professions (Lee *et al.,* 1992). Thus, project management can be defined as being:

- that which involves large complex tasks ,
- projects that have a definite beginning and end (it is not a continuous process),
- a management process that uses various tools to measure accomplishments and track project tasks,
- a project that frequently need resources on an ad-hoc basis as opposed to organisations that have only dedicated full-time positions, and
- a process that reduces risk and increases the chance of success.

Figure 2.2 illustrates the essential issues that need to be undertaken in the construction industry. At the same time, with out considering to these issues there is no guarantee for any project to be successful completed at the end of the project.

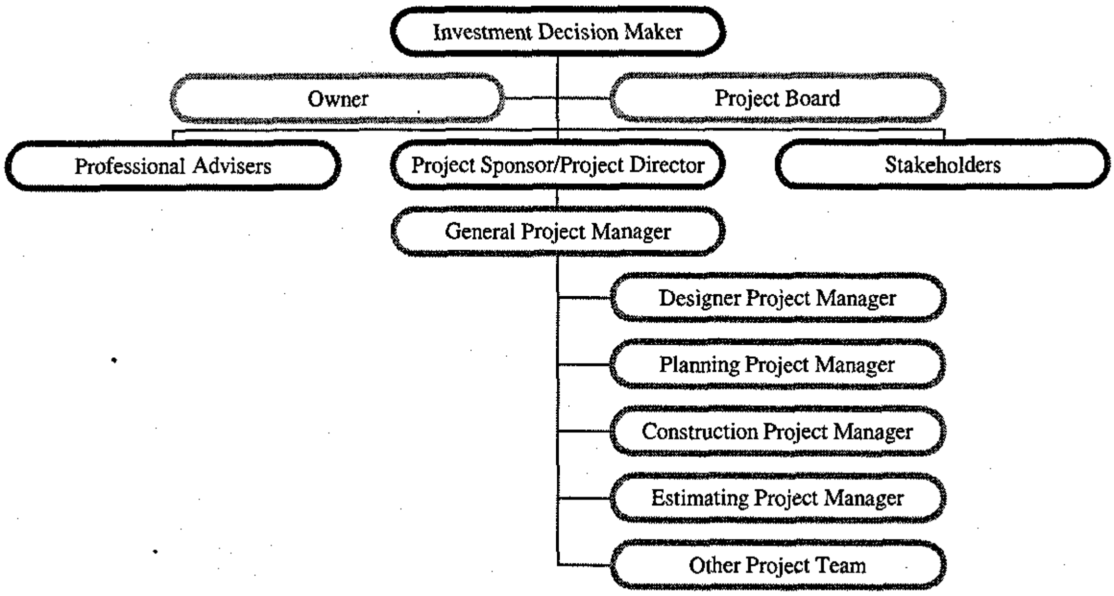
Figure 2.2 Modern Quality Management.



Therefore, the general project manager is an individual responsible for delivering the project (Willis et al., 1995). The general project manager leads and manages the project team, with the authority and responsibility to run the project on a day-to-day basis (Dulaimi et al., 1999).

Figure 2.3 illustrates all the key roles that could be involved, depending on the scale and/or complexity of the project, note that some of these roles could be combined and reporting lines shortened (Brown et al., 2000). For smaller and/or more straightforward projects, the roles of the project sponsor/director and construction manager may be combined subject to the proviso that the person taking on the combined responsibilities possesses the prerequisite competencies, expertise, experience and has the available time and resources (Boyd et al., 2001). Where roles are combined, it is essential that delegations and responsibilities are clearly understood and do not overlap with other roles (Blismas et al., 2004). This role description assumes that the roles of project sponsor/project director and construction manager are separate. Where the roles are combined with no separate interface, the project sponsor/project manager reports direct to the owner.

Figure 2.3 Project Functional Based.



Source: (Bhatt *et al.*, 2001).

At the same time, there are skills and attributes that CEPMs need in order for them to manage the project and meet standards specifications (Rounds *et al.*, 1985, Mustapha *et al.*, 1996, Love *et al.*, 2001 and Scutt *et al.*, 2004). Some of these skills are as follows:

- Apply standard project management approaches to the specific requirements of the project;
- Direct, manage and motivate the project team;
- Develop and maintain an agreed project plan and detailed stage plan(s);
- Tailor expert knowledge to meet specific circumstances;
- Plan the manage the deployment of resources to meet project milestones;
- Build and sustain effective communications with other roles involved in the project as required; and
- Apply quality management principles and processes.

Also, the CEPM in general should be appropriately trained in project management techniques and processes such as supervision of personnel, planning and scheduling etc. It is essential that the skills and experience of the construction manager are matched to the requirements of the project (Carmichael *et al.*, 1995).

2.2.2 Civil Engineering Project Managers (CEPM)

The CEPM is responsible for the day-to-day stewardship of construction projects (Wideman *et al.,* 2000) and establishes procedures and lines of the communication to monitor the progress of construction. The CEPM also develops and implements construction standards, specifications and methods of contracting (Walker *et al.*, 2002). It is a position of high responsibility and pressure that requires an individual with keen analytical skills, negotiating savvy, precise coordination, while at the same time achieving maximum efficiency while outside the office (Dulaimi *et al.,* 1999).

Thus, CEPMs plan and coordinate construction projects and they may be the owner or salaried employees of a construction management or contracting firm. Alternatively they may work under contract or as a salaried employee of the owner, developer, contractor, or management firm overseeing the construction project (Lee *et al.*, 1992). They may plan and direct a whole project or just a part of a project (Settle-Murphy *et al.,* 1997). CEPMs who work in the construction industry, such as general managers, project engineers, and others are increasingly called constructors (Koch *et al.,* 2003, and Lee *et al.*, 1992, Czuchry *et al.,* 2003, Woodward *et al.,* 1997 and Elsby *et al.,* 1981).

In recent times, CEPMs have had to meet the demands of increasing complexity in terms of technical challenge, product sophistication and organisational change (Smith *et al.*, 1995). Therefore, all projects should be aligned with achieving business strategy. Since the CEPM's job is to help an organization achieve a particular strategy, it is important that they know the basic business strategy. The management of construction projects requires knowledge of modern management as well as an understanding of the design and construction process (Bhatt *et al.*, 2001). Construction projects have a specific set of objectives and constraints such as a required time frame for completion (Chan *et al.,*. 2004, and Svensson *et al.,* 2003).

The management of construction and civil engineering projects requires knowledge of modern management as well as an understanding the design and construction processes (Mustapha *et al.,* 1996). CEPMs must be able to make decisions quickly as the construction environment changes throughout the project life cycle (Phua *et* *al.,* 2004 and Dulaimi *et al.,* 1999). This means that selecting and classifying the ability of the CEPMs is essential.

The construction industry is one of the biggest industries worldwide (Oxley *et al.*, 1996 and, Newcombe R., Langford D., and Fellows R., 1990) and includes new build, refurbishment and maintenance (Pheng *et al.*, 2001). Thus, some projects may involve only a few thousands pounds while others cost hundreds of millions. Some projects are simple, others complex; some may involve just two organizations; others may involve hundreds of suppliers, subcontractors and consultants (Grimshaw *et al.*, 1994 and Griffith *et al.*, 2000).

There is a growing movement towards certification of construction and civil engineering managers to ensure that a CEPM has a certain body of knowledge, ability and experience (Love *et al*, 2001). To meet and exceed customer expectations, the business team needs to follow an overall organizational strategy (Woodward *et al.,* 1997). The strategy is an agreed guide to action that should lead to success in the marketplace by satisfying customer needs better than the competition (Price *et al.*, 2003). However, no matter how well thought-out the strategy is, it is useless if implemented poorly or not implemented at all (Kesh *et al.*, 2002). In fact, a strategy that is poorly implemented or not implemented at all is really not a strategy; it is simply a plan, an intention to do something that remains undone (Kagioglou *et al.*, 1999). A true strategy is a plan that has been executed so that the consequences of carrying out the collective intention can be observed (Homes *et al.*, 2001). In most companies, a strategy is implemented through projects (Wideman *et al.*, 2004).

Generally, project management is an integrative function, any action cause failure to any stage of the project will have an impact on other stages (Wideman *et al.*, 2000). To successfully complete required deliverables, CEPMs must make informed trade-offs among objectives, coordinate and integrate various project management processes and continually manage complex interactions among the components of the project work through team members and other stakeholders (Chan *et al.*, 2004).

Persons interested in becoming a construction or civil engineering project manager need a solid background in building science, business and management, as well as related work experience within the construction industry (Heraty *et al.*, 1995 and Hwang *et al.*, 2003). They need to understand contracts, plans, specifications and be knowledgeable about construction methods, materials, and regulations (James S., 1994). Familiarity with computers and software programs for job costing, online collaboration, scheduling and estimating also is important (Kaka *et al.*, 2003). As a result, CEPMs are an important part of the construction and civil engineering team. Thus, managing a project is managing the application of capital to provide a required return so the business can satisfy its customer, shareholders and ultimately the business team. In the end, project success is based on the ability to first choose the right CEPM and then execute it successfully.

Therefore, due to the CEPM's responsibilities in project management process, a CEPM is an on site job supervisor or overseer and is a facilitator (Pheng *et al.*, 2001). The ideal CEPM does whatever it takes to ensure that the members of the construction project team can do their work (Willis *et al.*, 1986 and Diekmann *et al.*, 1986). At the same time, this means working with management to ensure they provide the resources and support required as well as dealing with team issues that are negatively impacting upon a team's productivity (Chan et al., 2004).

Given designs for buildings, roads, bridges, or other projects, CEPMs oversee the organization, scheduling and implementation of the project to execute those designs. They are responsible for coordinating and managing people, materials, equipment, budgets, schedules, contracts and safety of employees and the general public (Nguyen *et al*, 1988, and Dulaimi *et al*, 1999).

Due to the project size, on large projects, several different management systems may be used. For the general contractor system, the owner hires a general contractor to manage all activities (Newman *et al.*, 1996). Working for the contractor, CEPMs oversee the completion of all construction in accordance with the engineers and architects drawing and specifications and prevailing building codes (Newcombe *et al.*, 1990). They arrange for trade contractors to perform specialized craftwork or other specified construction work (Mutch *et al.*, 2002). On small projects, such as house modernisation, a self-employed CEPM or skilled trades worker who directs and oversee employees often is referred to as the construction contractors (Xiao H., *et al*, 2003).

In the construction management system, the owner hires a firm to oversee all aspects of the project (Nunnally *et al.*, 1987). The management firm will then hire a general contractor to run the construction process and oversee construction of the structure (Odeh *et al.*, 2002). In the design-build system, the owner, architects, general contractors, and major sub-contractors are brought together to cooperatively plan and design the project (Naoum *et al.*, 2003). The design-build group may be from an individual firm or a conglomeration of separate entities (Peurifoy *et al.*, 1970 and Osterberg *et al.*, 2004). The CEPM participates during the design process and may be in charge of the construction project once the design is agreed upon (Griffith A., Stephenson P., and Watson P., 2000).

Due to the CEPM's significance input into large complex construction projects, such as an office building or industrial complex, more than one manager may be required to manage the project (Sambrook *et al.*, 2000). Projects are usually divided into many segments but key stages normally include:

- site preparation, including land clearing and earth moving;
- sewage system;
- landscaping and road construction;
- building construction, including excavation and laying of foundations, as well as erection of structural framework, floors, walls, roofs; and
- building system, including fire-protection, electrical, plumbing, air-conditions, and heating (Woodward *et al.*, 1997).

Therefore, CEPMs may be in charge of one more of these activities and they will often work with engineers, architects, and others who are involving in the construction process (Samelson *et al.*, 1979, Sawczuk *et al.,* 1996 and Slaven *et al.*, 1997).

In addition, CEPMs evaluate and determine appropriate construction methods and the most cost-effective plan and schedule (Turner *et al.*, 1999). CEPMs divide all required construction site activities into logical steps, budgeting the time required to meet established deadlines (Bresnen *et al.* R *et al.*, 1986, Riggs *et al.*, 1988 and Groth *et al.*, 1997). This may require sophisticated estimating and scheduling techniques and use of computers with specialized software. They oversee the selection of trade contractors to complete specific pieces of the project-which could include everything from structural metalworking and plumbing to painting and carpet installation (Jackson *et al.*, 1986, Lange *et al.*, 1979 and Latimer *et al.*, 2002). Therefore, CEPMs determine the labour requirements and, in some cases, supervisor or monitor the hiring and dismissal of workers. They oversee the performance of all trade contractors and are responsible for insuring that all work is completed on schedule (Larson *et al.*, 2003).

CEPMs direct the whole project and monitor the progress of construction activities, sometimes through construction supervisors or other CEPMs and trade foremen (Lutzkendorf *et al.*, 2005). They oversee the delivery and use of materials, tools and equipment and the quality of construction, worker productivity and safety. They are responsible for obtaining all necessary permits and licenses and depending upon the contractual arrangement, direct or monitor compliance with building and safety codes and other regulations (Settle-Murphy, N., 1997). They may have several subordinates, such as assistant managers or superintendents, field engineers, or crew supervisors, reporting to them.

CEPMs regularly review engineering and architectural drawings and specifications to monitor progress and ensure compliance with plans and schedules (Skibniewski *et al.*, 1983 and Train *et al.*, 2001). They track and control construction costs against the project budget to avoid cost overruns (Turner *et al.*, 1999). Based upon direct observation and reports by subordinate supervisors, managers may prepare daily reports of progress and requirements for labour, material, machinery and equipment on the construction site (Vilkinas *et al.*, 2002). They meet regularly with owners, other constructors, trade contractors, vendors, architects, engineers and others to monitor and coordinate all phases of the construction project (Willis *et al.*, 1995).

Generally, project management is not just a technical process (Vilkinas *et al.*, 2002). It has become a very important business process (Love *et al*, 2004).

From a CEPM's viewpoint it is clear that the success of a particular project depends on how well that project helps to implement the overall strategy (Walker *et al.*, 1996). For example, some projects, such as new product developments, may be expected to return high levels of profit whereas other projects, such as entering a new geographic market, may be lucky just to break-even (Webster *et al.*, 1999). However, they could both be considered successful if they meet a strategic objective (Westland *et al.*, 1996). So although any given individual project may not produce a return to justify the investment, it may add value when it helps to achieve overall organization strategy (Wickramasinghe *et al.*, 2004). This is the first step in the business systems approach to project management – understanding that the new measures of project success involves the project's contribution to overall organization strategy (Ziyal *et al.*, 1995). Linking projects to strategy is one of the best ways to increase shareholder value (Cohen *et al.* 1997; and Englund *et al*, 1999).

2.3 THE TYPES OF PROJECTS

Since most owners are generally interested in acquiring only a specific type of construction facility, they should be aware of common industrial practice for the type of construction pertinent to them (Day *et al.,* 2004). Likewise, the construction industry is a conglomeration of quite diverse segment and products (Diekmann *et al.,* 1986). Some owners may procure a constructed facility infrequently and tend to look for short term advantages (Mills *et al.,* 2001). However, many owners require regular periodic acquisition of new facilities and/or rehabilitation of existing facilities (Willis *et al.*, 1995). It is to their advantage to keep the construction industry healthy and productive (Moore *et al.,* 1999). Collectively, the owners have more power to influence the construction industry than they realize because, by their individual actions, they can provide incentives or disincentives for innovation, efficiency and quality in construction (Ngai *et al.*, 1997). It is in the interest of all parties that the owners take an active interest in the construction and exercise beneficial influence on the performance of the industry (Nguyen *et al.,* 1988).

In planning for various types of construction, the methods of procuring professional services, awarding construction contracts and financing the constructed facility can be quite different (Baracco *et al.,* 1987 and Dunlop *et al.,* 2004). For the purpose of discussion, the broad spectrum of constructed facilities may be classified into four major categories, each with its own characteristics (Molleman *et al.*, 2003).

i- ***Residential Housing Construction***- residential housing construction includes single-family houses, multi-family dwellings, and high-rise apartments (Abdul-Aziz *et al.*, 2002). During the development and construction of such projects, the developers or sponsors who are familiar with the construction industry usually serve as surrogate owner and take charge, making necessary contractual agreements for design and construction and arranging the financing and sale of the completed structures (Helper *et al.,* 1991). Residential housing designs are usually performed by architects and engineers and the construction executed by builders who hire subcontractors for the structural, mechanical, electrical and other specialty work. The residential housing market is heavily affected by general economic conditions, tax laws, the monetary and fiscal policies of the government (Kicklighter *et al.,* 1995). Often, a slight increase in total demand will cause a substantial investment in construction, since many housing projects can start at different locations by different individuals and developers at the same time. Because of the relative ease of entry, at least at the lower end of the market, many new builders are attracted to the residential housing construction. Hence, this market is highly competitive, with potentially high risks as well as high rewards (Sherwood *et al.,* 1997).

ii- ***Institutional and Commercial Building Construction***- institutional and commercial building construction encompasses a great variety of project type and sizes, such as schools and universities, medical clinics and hospitals, recreational facilities and sports stadiums, retail chain stores and large shopping centres, warehouses and high manufacturing plants, skyscrapers for offices and hotels (Lützkendorf *et al.,* 2005). The owners of such buildings may or may not be familiar with construction industry practices but they usually are able to select competent professional consultant and arrange the financing of the constructed facilities themselves (Avelino *et al.,* 1984). Specialty architects and engineers are often engaged for designing a specific type of buildings, while the builders or general contractors undertaking such projects may also be specialized in only that type of building (Cornick *et al.,* 1991). At the same time, because of the higher costs and greater sophistication of institutional and commercial buildings in comparison with residential housing, this market segment is shared by fewer competitors. Since the construction of some of these buildings is a long process which once started will take some time to proceed until completion, the demand is less sensitive to general economic conditions than that for speculative housing (Knoepfel *et al.,* 1989).

iii- ***Specialized Industrial Construction***- specialized industrial construction usually involves very large scale projects with a high degree of technological complexity, such as oil refineries, steel mills, chemical processing plants and coal-fired or nuclear power plants (Bennett *et al.,* 1980). The owners are usually deeply involved in the development of a project, and prefer to work with designers-builders such that the total time for completion of the project can be shortened (Langford *et al.,* 1991). They also want to select a team of designers and builders with whom the owner has developed good working relations over many years (Gidado *et al.,* 1992). Although, the initiation of such projects is also affected by the state of the economy, long range demand forecasting is the most important factor since such projects are capital intensive and require considerable amount of planning and construction time.

iv-***Infrastructure and Heavy Construction***- Infrastructure and heavy construction includes projects such as highways, mass transit system, tunnels, bridges, pipelines, drainage system and sewage treatment plants (Pheng *et al.,* 2001). Most of these projects are publicly owned and therefore financed either through bonds or taxes (Price *et al.,* 2003). This category of construction is characterized by a high degree of mechanization, which has gradually replaced some labour intensive operations (Proverbs *et al.,* 1999). Engineers and builders engaged in infrastructure construction are usually highly specialized since each segment of the market requires different types of skills (Rounds *et al.,* 1985 and Smith *et al.,* 2002). However, demands for different segment of infrastructure and heavy construction may shift with saturation in some segments (Tatum *et al.,* 1987). For example, as the available highway construction projects are declining, some heavy construction contractors quickly move their work force and equipment into the field of mining if jobs are available (Walker *et al.*, 2002).

In all cases, generally, the construction projects need leaders (Armandi *et al.,* 2003). People who able to command attention, direct others to action and think quality to produce results (Battikha *et al.,* 2003). This is the case whether the construction might be roads, bridges, dams, sewage treatment plants, water towers, or host of other structures that require the combination of people and materials to get the job done (Blismas *et al.,* 2004).

2.4 MANAGING AND CONTROLLING THE CONSTRUCTION PROJECT

The task is to manage the construction project as it progresses, using project control systems to maximum advantage (Kelley *et al,.* 2002). Project control is best analyzed by applying the factors of a unique operation, following its output and measuring its results (Diekmann *et al.*, 1986 and Cornick *et al.*, 1988). The factors to be considered are labour, materials and equipment. One might also have to consider the role of the subcontractors, as they affect the sequencing of this task. In measuring the factors, the CEPM must key in on the productivity of this labour force, measuring output over a given period time (Li *et al.*, 1997 and Xiao *et al.*, 2003). From these results, the CEPM can then make a comparison against the project estimate and against the objectives to meet the expected goals.

To be effective in managing the project, the CEPM must exercise some factors of operation. Which included the planning, communication and monitoring the project (Teijlingen *et al.*, 2001). Generally, the project must be well planned, each factor of the plan properly communicated, carefully monitored and controlled. Proper planning involves one of the initiatives of the goal setting process, the preparation of the schedules and budgets established to monitor all phases of construction. The contract and contract documents are used to compile this information. It must be the commitment of the project superintendent and labour forces to carry out the tasks within these limits.

To properly implement the plan, one must communicate it in such a fashion that there is full understanding of its intent (Scutt *et al*,. 2004). One successful mode is the construction schedule. This guide to the project must clearly show each activity, starting and finishing dates, duration, resources, long lead item purchasing schedule, submittal dates, purchasing dates all tied together by meaning relationships, the networking between tasks. As the plan progresses and careful concise communications have taken place, there exists the possibility that one facet of the schedule may be interrupted causing a disruption sorely affecting the outcome of the schedule. Through careful monitoring by the CEPM and the control mechanisms implemented, an analysis of the effects of this obstruction can be made and any necessary adjustments to carried out. Quite often issues arise that represent change to the initial planning of the schedule; these include: unanticipated material delays, modification to the design, additional scope and contract payment delays (MacNeil *et al.,* 2004).

This communication must include the updated time and cost impacts, show graphically on schedule and in the form of a pending change order with appropriate backup. A well thought out issue letter would contain language that identifies to the owner the means and methods to bring the project back on schedule, the possible premium time affects on trades and the costs general conditions affects associated with these additional working hours (Mustapha *et al.*, 1996). When possible, at the start up of the project, a contingency in the schedule should be initiated, which could allow for the reassignment of labour duties, on an as-needed basis, to protect the project from avoidable delays.

2.5 SUMMARY

All contract work must be satisfactorily completed, outstanding claims resolved, change orders fully negotiated and processed, extension of time reports approved, operations and maintenance manuals approved, as-built drawings completed and all other contract goals achieved. In addition, all certifications and warranties must be in place. A proper project plan must also conform to the client's established procedures.

The goal of effective construction project management is to integrate the design and construction phases of a project while keeping it on schedule and within budget, and ensuring a completed product of the highest quality. To ensure that all project objectives are fully met, CEPMs utilise their engineering skill, experience, and knowledge of construction contracting to develop realistic schedules, prepare accurate construction estimates, analyse alternative designs, study labour conditions, perform value engineering and effectively coordinate the activities of the construction team.

Within this chapter, a comprehensive literature review has been conducted on the topic of construction project management and the role of the CEPM within it. The chapter also considered the types of construction project and how to effectively manage and control these. In combination, this work reveals that the management of a project in the UK construction industry can be an extremely complex and demanding task to undertake.

CHAPTER _3_
Modern Civil Engineering Project Managers

3.0 INTRODUCTION

The idea behind construction management is that a team is created at the onset of the project conception (Baracco et al., 1987 and Barber et al., 1992). The client's most important task is selecting team members who will include a CEPM, an engineer and an owner representative (often an architect) (Czuchry et al., 2003). Once selected, the architect is responsible for defining the project through drawings and specifications (Cornick et al., 1988) (Culpan et al., 2002). The owner, who is thoroughly informed by these professionals, is then able to make educated decisions about the project. The prime reason why construction management works is because it offers exacting control over construction costs, time span and quality gained during the early design phase, continuing through the project's completion (Dulaimi et al., 1999).

Construction management is the administration, management, and coordination of all aspects of an engineering project (Halpin et al., 1980, Murray et al., 1981 and Carr et al., 1997). The engineering project can take many forms; from the design and construction of office buildings, housing subdivisions, industrial facilities, skyscrapers, roads, bridges, dams, utility projects, to an endless variety of other projects (Kenneth et al., 1993). The project can be for new construction or improvements to an existing facility that is owner to regulatory driven (Belout et al., 1992). Each project has its own special needs and requirements that need to be understood and engineered (Bhatt *et al.*, 2001).

The CEPM is an individual or group of people that ensure a project is properly designed, engineered and constructed within a specified time period for a given, usually budgeted, amount of money (Mustapha *et al., 1996*). Once a project has been designed it is put out to bid where general contractors submit written proposals to perform the contractual work (Mutch *et al.,* 2002). Traditionally, the CEPM is known to be the client's agent but it is important to recognise that the general contractor also has a CEPM (Xiao *et al.,* 2003). Throughout the construction phase of a given project, the two CEPM's work together to complete the project to the satisfaction of the client and the contract documents. Each performs similar functions and they share the common goal of completing the project, however, their responsibilities can be very different.

The main task of the CEPM is improving the whole performance of the project. However, it is important that CEPMs identify whether each employee is in the right role or not. Additionally, CEPMs need to work with each person and to contribute to the performance within the organization, means.

3.1 PRECONSTRUCTION SERVICES

Preconstruction services are typically defined as those services performed prior to the actual start of construction (Abdul-Aziz *et al.,* 2002). A benefit of hiring a CEPM early in the planning stages of a project is the ability to utilise their construction expertise in all aspects of the design and planning (Barber *et al.,* 1992). With a CEPM employed early in the planning stages, the project team typically consists of the owner, the engineers and the CEPM (Bresnen *et al.*, 1986). Each team member has a role that should be defined at the beginning of the project (Battikha *et al.,* 2003). Although each project is unique, the tasks typically undertaken by the CEPM will include:

- Review project needs, goals and priorities.
- Evaluate the project budget and program.
- Evaluate the project time schedule.
- With regards to schematic design:
  - i. Prepare a schematic design estimate;
  - ii. Monitor the evolving design and make suggestions;
  - iii. Consult with the owner and architect on means and methods of construction;
  - iv. Review schematic design documents;
  - v. Submit input to the owner and architect relative to time and cost control;
  - vi. Identify certain areas of phases construction; and
  - vii. Prepare a preliminary project schedule, including the design phase.
- With regards to design development:
  - i. Evaluate the design development documents;

ii. Prepare a detailed estimate based on available design drawings or subcontractor bid format to ensure that the project is within budget;
iii. Analyse the project for potential alternative equipment, material and system selection for cost savings;
iv. Prepare trade-off studies relative to value engineering;
v. Review and update the project schedule;
vi. Review project for constructability;
vii. Discuss project with subcontractors and material suppliers to determine work loads, bonding capacity availability, worker/mechanic availability, etc. ; and
viii. Prepare a site use study to be used for allocation of space for storage, parking and temporary facilities.

- With regards to construction documents:
  i. Prepare and update estimates in the CSI format, and budgets and time schedules, at appropriate points in the working drawings stage. Care should be taken to ensure that an excessive number of estimating points do not hinder the schedule and flow of the project;
  ii. Review the drawings and specifications and make comments and suggestions;
  iii. Develop a detailed CEPM network schedule; and
  iv. Prepare an estimate for the cost of advertising and printing of proposal documents.

- Soliciting subcontractors/vendor lump sum/competitive sealed proposal:
  i. Organise and distribute construction documents and other contractor and district bid requirements for seeking lump sum or competitive sealed proposals;
  ii. CEPM shall advertise for sealed competitive or lump sum proposals.
  iii. Conduct as necessary, pre-proposal meetings; and
  iv. Respond to questions concerning schedule and sequencing and forward questions from bidders to the architect.

- With regards to receiving proposals:
  i. Receive all proposals;
  ii. Review proposals for compliance contract documents and prepare proposal tabulations;
  iii. Review subcontractor/vender qualifications, past experience and other key factors; and
  iv. Make recommendations for subcontractor/vender awards.

3.3 CIVIL ENGINEERING PROJECT MANAGERS'S ESSENTIAL DUTIES & RESPONSIBILITIES

The following points are the most essential duties for the CEPM:

- Develop and manage relationships between the construction division and property management, tenants, contractors, administration and accounting.
- Develop preliminary estimates on buildings including hard and direct soft costs in order to establish the construction budget.
- Develop a preliminary project master schedule.
- Inspect potential properties, complete an inspection checklist and report to the project development team.
- Research design parameters based on requirements of local codes, moderate rehabilitation and historic review, including coordination input from property management on long-term maintenance issues.
- Identify areas of negotiation and/or waiver with local agencies.
- Develops standards and outlines specification compatible with budgets.
- Conduct value engineering for alternative materials and methods.
- Recommend the feasibility of new construction and rehabilitation projects.
- Coordinate the development of detailed specifications along with architects and contractors and prepare bid documentation.
- Prepares preliminary construction estimates and construction schedules.
- Coordinate approvals, inspections and contract work with government agencies and utilities.

- Research track record, qualifications and references of construction team members and prepare recommendations to executive management on the selection of members of the construction team (Battikha *et al.,* 2003).
- Coordinate the execution of construction documents, including the inclusion of all attachments (Oxley *et al.,* 1996).
- Develop and implement cost control systems, reporting procedures, contingency and damage control. Coordinate with project development staff to resolve unexpected expenditure related issues.
- Monitor construction work under taken by contractors, attend project progress meetings, negotiate and authorize draws in relation to construction design.
- Keep detailed accounting of construction expenditures.
- Coordinate with property management for relocations and marketing issues.
- Prepare and oversee time scale of the project and follow.
- Perform post-construction evaluation, including the facilitation of the certificate of occupancy, final close out and return over to property management.

Thus, CEPM's work out of a main office from which the overall construction project is monitored, or out of a field office at the construction site (Mustapha *et al.,* 1996). Advances in telecommunications and internet access allow CEPM's to be onsite without being out of contact of the office (Merna *et al.,* 1990). Management decisions regarding daily construction activities generally are made at the jobsite (Brache *et al.*, 1988). CEPM's usually travel when the construction site is located in another place (state) or when they are responsible for activities at two or more sites. Management of overseas construction projects usually entails temporary residence in another country (Harris *et al.*,1996).

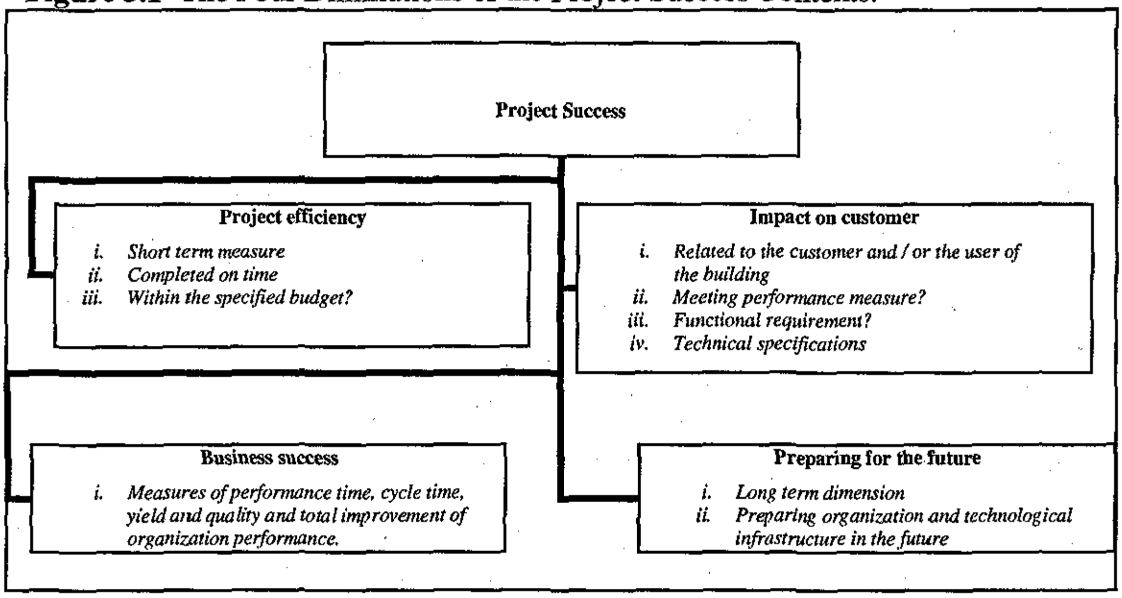
CEPM's may be on call often 24 hours a day, to deal with delays, bad weather or emergencies on the site (Nguyen *et al.,* 1988 and Oglesby *et al.*, 1990). Most work more than a standard 40-hour week because construction may proceed around-the-clock (Ondari *et al.,* 1999). They may have to work this type of schedule for days, even weeks, to meet special project deadlines, especially if there are delays (Fraser *et al.*, 2000).

3.4 CRITERIA FOR PROJECT SUCCESS

Munns and Bjeirmi (1996) consider a project as the achievement of a specified objective, which involves a series of activities and tasks that consume resources. The Oxford Dictionary (1990), defines a project as a standard of judgement or principle by which something is measured for value. Lim and Mohamed (1990) advocate a criteria as a principle of standard by which anything is or can be judged. The Oxford Dictionary further defines success as a favourable outcome or the gaining of fame or prosperity. Finally, when combining these terms (standard of judgement or principle), the criteria of project success can be defined as the set of principles or standards by which favourable outcomes can be completed within a set specification.

Shenhar et al., (1997) proposed that project success is divided into four dimensions. Figure 3.1 shows these four dimensions that are time-dependent. The first dimension is the period during project execution and immediately after project completion. The second dimension can be assessed after a short time, when the project has been delivered to the customer. The third dimension can be assessed after a significant level of sales has been achieved (one to two years). Finally, the fourth dimension can only be assessed three to five years after project completion.

Figure 3.1 The Four Diminutions of the Project Success Contents.



Source: (Shenhar *et al.*,1997)

Generally, the CEPM should avoid dealing with risks in an arbitrary manner because analysis, realism and innovation are all required to ensure that the project is successful. To recognize, evaluate and adjust to problems, make a choice and provide follow-up are all aspects which must be addressed, though those CEPMs that inevitably err on the side of caution will fall into the risk-aversion category.

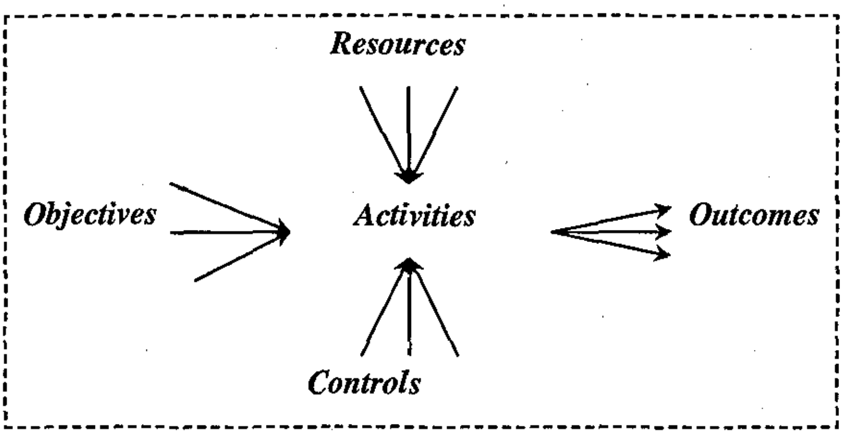
Organizations select people to manage cross-functional projects based on their high levels of personal productivity and their aptitude to complete projects (Carmichael *et al.,* 1995). CEPM's are typically task-oriented people with a strong sense of urgency and a keen focus on getting started and finishing (Bourne *et al.* 2004). There are however many factors that are outside a manager's control, such as government policies, weather conditions, strikes in other industries, etc. and therefore, it must be understood that industrial managers will never have absolute control (Hicks *et al.,* 1996 Kelley *et al.,* 2002 and Blismas *et al.*, 2004)

Management control is progressive and involves continually making adjustments to perceived possibilities of the situation as a whole, after making comparisons between planned and actual results (Smith *et al.* 2004). Therefore, CEPM's direct and monitor the progress of construction activities, sometimes through construction supervisors or other CEPMs.

Hence, construction project management has been defined as the change process required to deliver an outcome within a set of constraints (Chua *et al.*, 1999) as show in Figure 3.2. Like any process, project management can be broken down into a discrete set of basic elements namely:

- Objectives;
- Resources;
- Activities;
- Controls; and
- Outcomes.

Figure 3.2 The Relationship Between these Elements.



CEPMs are required to create an internal company environment which enables decisions to be made and jobs to be performed in the light of the need for the company to prosper (Canter *et al.,* 1993).

Under the traditional form of procurement, the CEPM function aims to assist in construction as required by the contract and this will include attention to; safety of the permanent and temporary, safety of personnel, quality of materials and workmanship, construction progress and financial control, etc. (Elsby *et al.,* 1981). CEPMs are continually having to make decisions about methods of operation and the right mix of men and machines within a working environment (Canter *et al.,* 1993).

3.4 ESSENTIAL SKILLS FOR CIVIL ENGINEERING PROJECT MANAGERS

Successful construction projects rarely happen by themselves. They must be planned and executed. To be successful, construction projects must also have a responsible and empowered CEPM to drive, direct and monitor the construction project. The selection of a CEPM has a major effect on the success of the construction project. The CEPM is the person with the education, background and knowledge to manage the size of design and construction projects pertinent to the level at which he/she is assigned (Goodman *et al.*, 1997, Carmichael *et al.*, 1995 and Suhanic *et al.*, 1997). CEPM should have the skill, knowledge and personality to bring the project to fruition. The CEPM need both management and technical skills. The key management skills are those needed to perform or direct project management activities and are listed below:

3.4.1 Motivating

Since motivation influences productivity, CEPM's need to understand what motivates employees to reach peak performance (Graham *et al.*, 1982). It is not an easy task to increase employee motivation because employees respond in different ways to their jobs and their organization's practices (Alderman *et al.*, 1999). Motivation is the set of processes that moves a person toward a goal (Stipek *et al.*, 2000). Thus, motivated behaviours are voluntary choices controlled by the individual employee. The CEPM's (motivator) must influence the factors that motivate employees to higher level of productivity (Levitt *et al.*, 1984). At the same time, there are factors that affect work motivation and include: individual differences; job characteristics; and organizational practices (Briscoe *et al.*, 2000). Individual differences are the personal needs, values, attitudes, interests and abilities each individual within the project team bring to the job. Job characteristics are the aspects of the position that determine its limitation and challenges (Samelson *et al.*, 1979). Organizational practices are the rules, human resources policies, managerial practices and rewards system of an organization. CEPMs must consider how these factors interact to affect employee job performance and in addition, know how to get maximum performance out of individuals within the project team (Mansfield *et al.*, 1999 and Cheng *et al.*, 2001).

3.4.2 Record keeping

Every project is different when it comes to capturing and reporting information. The challenge is to take time every day to record daily activities. So that when problems occur and thus, clarification is needed, a portfolio of historical information is readily available (Latimer *et al.,* 2002).

3.4.3 Project Team/Coordinating

Many problems may be encountered on a large construction project, thus making it necessary to coordinate the efforts of the various parties involved, including the owner, contractors, designers, utility companies, as well as other involved agencies (Lee-Kelley *et al.,* 2002). The essential element required to coordinate these many entities is having the right personnel on the job (Moore *et al.,* 1999). Better coordination is becoming the most sought after attributes in managing today's mega projects involving multiple participants or stakeholders (Lim *et al.*, 1999). The objectives of each stakeholder vary and it becomes very important under such situations to have a partnering approach and not a confrontationist approach since that will result increased project costs (Pinto *et al.*, 1988). Better coordination is not only required for internal members of the organisation but is needed with external agencies as well. Finally, lack of coordination on both the fronts may result in overshooting of project costs. Since a project is dependent on a number of individuals representing different departments, lack of coordination may result in duplicity of work, delay in work done due to varying priorities of each one involved with the project, which finally leads to increase in cost. Similarly lack of coordination with external agencies also results in lack of synchronisation of different activities performed at site resulting into cost overrun in s project (Sawczuk *et al.,* 1996).

3.4.4 Making Work Assignments

Asset-intensive companies such as AMEC often have large numbers of employees and equipment. However, without the appropriate management tools, these resources can become over, or under-used, or can even be assigned to jobs that are simply not in line with the capabilities of the resources (Albert *et al.,* 1992). CEPMs need a way to efficiently and effectively assign human or equipment resources to work orders, matching work order requirements to resource availability, skills and locations (Koch *et al.,* 2003). Once resources are assigned, CEPMs must also be able to monitor job status to ensure adequate capacity and timely completion (Mustapha *et al.*, 1996).

CEPMs therefore define the available capacity of resources by setting up a base calendar which details available working hours (Gee *et al.,* 1993). The CEPMs also overrides regular work hours with holiday and personal time schedules so that resources available at any given time are known, regardless of circumstance. At any time, CEPMs can review resource assignment information to determine whether resources are working at full capacity (Bell *et al.*, 1986, Baccarini *et al.*, 2001 and Andersen *et al.,* 2000).

Once an assignment of resources has been made, the CEPMs can still make changes to project requirements provided other members of the team are kept informed. Resource assignment allows the CEPMs to display all the current assignments for a particular task and update assignments to balance the load. The CEPMs can also add, update, or delete assigned resources, assignment hours and start and end dates, assignment percentages and competency information (Griffith *et al.*, 2000).

3.4.5 Making personal decisions

Decision making is a fundamental skill for CEPMs (Stevens *et al.,* 1986 and Barber *et al.,* 1992). Much of what CEPMs do is to solve problems and to make informed decisions but often problems are solved and decisions made by reacting to them (Willis *et al.,* 1986). All too frequently, the decision making process is stressed and CEPMs have very little time. Management decisions regarding daily construction activities are usually made at the job site (Birdir *et al.,* 2002).

Failures, poor performance or low productivity during construction may force CEPMs to make critical decisions; these decisions must to be made in a rational and time-responsive manner. Consequently, CEPMs usually travel when the construction site is in another state or when they are responsible for activities at two or more sites (Bresnen *et al.,* 1986).

3.4.6 Setting goals

Successful projects need not be elusive and simple, practical and tangible techniques yield excellent and repeatable results (Terborg *et al.,* 1978). Project orientation first involves setting goals for the project (Wade *et al.,* 2004). An understanding of the owner's contract documents, selected contract type, general requirements, specifications and plans combined with the estimate and scope of work are mandatory requirements (Day *et al.,* 2004). The review should allow the CEPM ability to develop the project construction schedule, pre-purchase log, financial projections yielding the cost and time limitation to the project.

3.4.7 Communicating

Communication is perhaps one of the most important functions of a CEPM and yet sometimes, the least understood; without people there is no activity but without communication there is no action (Mason *et al.,* 1978 and Guercini *et al.,* 2004). Consequently, communication must be relevant, reliable and timely. It must inform in both technical and non-technical terms and above all, it must be concise and understandable to avoid mistakes and save time. In the past, a good CEPM might have been a poor communicator and would have remained employable (Mason *et al.,* 1978 and Carmichael *et al.,* 1995). Generally, this dearth in ability would not be well received by clients but as long as the CEPMs delivered the goods, the client would accept the situation (Larson *et al.,* 2003). In today's new IT world, however, projects need to be undertaken in partnership with the business side and this partnership absolutely requires solid communication (Ziyal *et al,*. 1995). In fact, many of the problems that surface on a project are actually the result of poor communication (Albert *et al.,* 1992). Once communication begins to fail, CEPMs will see the success of the project begin to fail as well (Galliers *et al.,* 1987).

Communication, consists of exchanging routine information and processing either electronic or paper based materials. Communication includes answering procedural questions, receiving and disseminating requested information, conveying the results or meetings, giving or receiving routine information over the phone, processing mail, reading reports, writing reports/memos/letters, routine financial reporting bookkeeping, and general desk work (Larson et al., 2003).

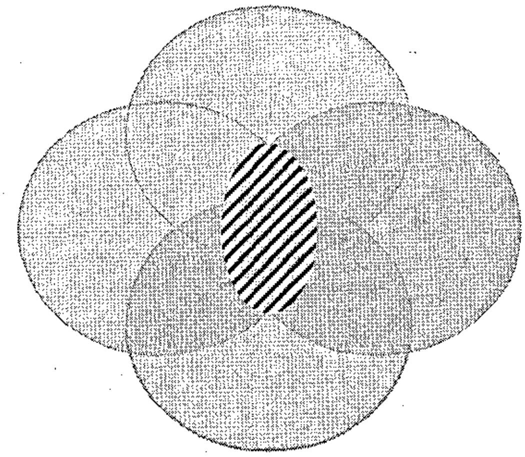
The main objective of the CEPM is to get a specified task done in an organized way and to have this delivered on a preset date (Chapman *et al.*, 1997). Project management requires a high degree of organizational and communicational skills (Frank *et al.*, 1992, Battikha M. G 2003., and Walker D. H. T., *et al.* 2002). In project management people are at the centre of projects and:

- Determine how or if a project will succeed;
- Define project goals; and
- Plan, organize, direct, coordinate and monitor project activities.

3.4.8 Training

The CEPM must be a good team leader and team player, participative, non-threatening, open-minded, a good listener, fair minded, able to see things from competing points of view, a problem solver with the ability to steer not simply a middle course but a winning course in terms of the project's objectives and see decisions through (MacNeil *et al.*, 2004). A CEPM should know about the organisation, the field of work and managerial functions (e.g. monitoring and evaluation) as well as communication skills; they should also have an ability and willingness to learn sensitivity, flexibility and leadership (Torrington *et al.*, 2002).

Figure 3.3 Basic Ingredients in Project Management.



The basic ingredients for a project management framework may be presented schematically in Figure 3.3. A working knowledge of general management and familiarity with the special knowledge domains related to the project are indispensable. Supporting disciplines such as computer science and decision science may also play an important role. In fact, persons interested in becoming a CEPM need a solid background in building science, business and management, as well as related work experience within the construction industry (Carmichael *et al.,* 1995). They need to be able to understand contracts, plans, and specifications and to be knowledgeable about construction methods, materials and regulations. Familiarity with computers and software programs for job costing, scheduling and estimating is increasingly important (Cornick *et al.,* 1991).

3.4.9 Controlling

New, more organic forms of organizations (self-organizing organization, self-managed teams, network organizations, etc.) allow organizations to be more responsive and adaptable in today's rapidly changing world (Wideman *et al.,* 1989). These forms also cultivate empowerment among employees, much more than hierarchical, rigidly structured organizations of the past (Cheng *et al.,* 2001). Many people assert that the nature of organizations has changed (Dale *et al.,* 1990). Some argue that management should not exercise any form of control whatsoever (Cordell *et al.,* 1986). They claim that management should exist to support an employee's efforts to be fully productive members of organizations and communities (Elsby *et al.,* 1981). Therefore, any form of control is completely counterproductive to management and employees (Culpan *et al.*, 2002).

Several academics react strongly against the phrase management control. The word itself can have a negative connotation, for example, it can sound dominating, coercive and heavy-handed (Connor *et al.,* 1985). It seems that writers of management literature now prefer use of the term coordinating rather than controlling (Griffith *et al.*, 2000).

Regardless of the negative connotation surrounding the term control, it must exist or there is no organisation at all (Ahmed *et al.,* 1998). In its most basic form, an organization is two or more people working together to reach a common goal. Whether an organization is highly bureaucratic or changing and self-organizing, the organization must exist for some reason, some purpose, some mission (implicit or explicit), or it is not an organization at all. These strategies are agreed upon by members of the organization through some form of communication, formal or informal (Wade *et al.,* 2004). Members then set about enacting agreed decisions.

This form of ongoing communication to reach a goal, tracking activities, toward the goal and then subsequent implementing decisions about what to do is the essence of management coordination (Fox *et al.*, 1984). It needs to exist in some manner – formal or informal (Diekmann *et al.,* 1986).

3.4.10 Planning

During the first part of any project, the CEPM must carefully define and plan the project (Gallon *et al.*, 1994). The result is a project definition which also called a project charter or a project work plan (McCredie *et al.*, 2000). The work plan is a vital tool for ensuring that the CEPM and project team know what needs to be done to complete the project. If the work plan goes unchecked, then the project team runs the risk of diverging from the plan; a misstep can result in project failure.

In the planning of facilities, it is important to recognize the close relationship between design and construction (Sacerdoti *et al.*, 1977 and Schneider *et al.*, 2003). These processes can best be viewed as an integrated system. Broadly speaking, design is a process of creating the description of a new facility, usually represented by detailed plans and specifications. Hence, construction is the implementation of a design envisioned by architects and engineers.

Several characteristics are unique to the planning of constructed facilities and should be kept in mind at the very early stages of the project life cycle (Elsby *et al.*, 1981). These are that:

- Nearly every facility is custom designed and constructed and often requires a long time to complete.
- Both the design and construction of a facility must satisfy the conditions peculiar to a specific site.
- Because each project is site specific, its execution is influenced by natural, social and other locational conditions such as weather, labour supply, local building codes, etc.
- Since the service life of a facility is long, the anticipation of future requirements is inherently difficult.
- Because of technological complexity and market demands, changes of design of plans during construction are not uncommon.

In an integrated system, the planning for both design and construction can proceed almost simultaneously, examining various alternatives which are desirable from both viewpoints and thus, eliminating the necessity of extensive revisions under the guise of value engineering (Zhang *et al.*, 2005). Furthermore, the review of designs with regard to their constructability can be carried out as the project progresses from planning to design.

For example, if the sequence of assembly of a structure and critical loadings on the partially assembled structure during construction are carefully considered as a part of the overall structural design, the impacts of the design on construction falsework and on assembly details can be anticipated (Gaylord *et al.*, 1979). However, if design professionals are expected to assume such responsibilities, they must be rewarded for sharing the risks as well as for undertaking these additional tasks (Herbert *et al.*, 1998). Similarly, when construction contractors are expected to take over the responsibilities of engineers, such as devising a very elaborate scheme to erect an unconventional structure, they too must be rewarded accordingly (Abdul-Aziz *et al.*, 2002). As long as the owner does not assume the responsibility for resolving this risk-reward dilemma, the concept of a truly integrated system for design and construction cannot be realized (Wideman *et al.*, 2000).

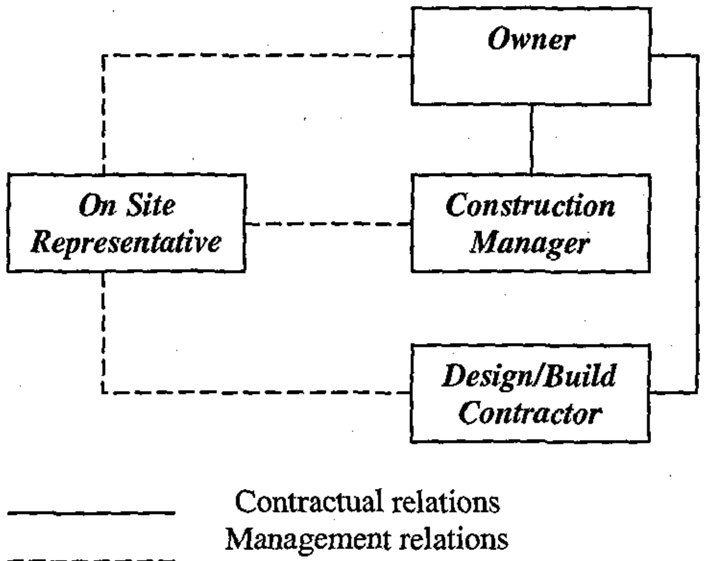
3.4.11 Leading

For many long-term projects, effective project management will allow for contingencies such as changes in staff, changes affecting the project's scope and implementation and changes to estimated time and resource requirements. The leading of projects almost inevitably involves introducing change and innovation, working under pressure and getting the best out of the project team (Harrigan *et al.*, 1996 and Lewis *et al.*, 1997). The project will usually be judged as successful; if it meets the targets set by the client (Burke *et al.*, 1993).

Skills needed to manage projects are the same as those required in everyday management situations but in addition, managing a project will usually mean that CEPMs are also dealing with a new situation, working with new people or using an untried combination of resources (Barber *et al.*, 1992). It is therefore important for CEPMs to fully utilise the special skills of fellow team members and work effectively with their individual preferences, work styles and temperaments (Mustapha *et al.*, 1996). A CEPM must be a leader and will be required to think and act differently from followers, using innovation and personal values to help guide their actions, instead of following prescribed or rulebook solutions (Newcombe *et al.*, 1990).

The CEPM position fundamentally aims to protect the owner's interests (Cheng *et al.*, 2003). Therefore, the CEPM is sometimes also called the owner's representative. Due to the technological advancement of materials and processes, transportation and communications, the management of construction projects have also become more sophisticated and complex (Page *et al.*, 2002). The level of sophistication of a construction project is dependent upon the size and duration of the actual project. Some construction projects are adequately administrated with a minimum of contractual agreement and a basic system of project supervision. The relationship between the CEPM and contractor is presented in Figure 3.4 (Nunnally *et al.,* 1987).

Figure 3.4 Owner - Contractor- CEPM Relationship.



While a successful CEPM must be a good leader, other members of the project team must also learn to work together, whether they are assembled from different divisions of the same organization or even from different organization (Settle-Murphy *et al.*, 1997). Some problems of interaction may arise initially when the team members are unfamiliar with their own roles in the project team, particularly for a large and complex project. These problems must be resolved quickly in order to develop an effective, functioning team (MacNeil .,*et al.*, 2004).

Many of the major issues in construction projects require effective interventions by individuals, groups and organizations (Pheng *et al.*, 2001). The fundamental challenge is to enhance communication among individuals, groups and organizations so that obstacles in the way of improving interpersonal relations may be removed (Larson *et al.*, 2003). Some behaviour science concepts are helpful in overcoming communication difficulties that block cooperation and coordination (Lee *et al.*, 2002). In very large projects, professional behaviour scientists may be necessary in diagnosing the problems and advising the personal working on the project. The power of the organization should be used judiciously in resolving conflict (Grimshaw *et al.,* 1994).

3.5 WHY CIVIL ENGINEERING PROJECT MANAGERS FAIL

There is probably no other discipline that is more difficult than CEPM (Davenport *et al.*, 1996 and Mills *et al.*, 2001). The general goal seems simple enough i.e. build a project on-time, within budget, with the stated quality standards and in a safe environment (Turner *et al.*, 1999). Many projects do end successfully, while many others are outright disasters (Wideman *et al.*, 2000 and Liebowitz *et al.*, 1998). However, some projects end up in the grey area on the project success scale (Harris *et al.*, 1996). It is common to complete a project but sometimes over the deadline or over the budget, or completed with a dissatisfied client or a miserable team (Wideman *et al.*, 1989 and Larson *et al.*, 1999).

During the first part of any project, the CEPM must carefully define and plan the project (Andersen et al., 2000 and Birdir *et al.*, 2002). The result of defining a project is the completion of a project definition (also called a project charter). The result of planning the project is the project work plan (Clough *et al.*, 1991 and Culpan *et al.*, 2002). The work plan is a vital tool for ensuring that the CEPM and project team know what need to do to complete the project. If the CEPM allow the work plan to go unchecked, they run the risk of diverging from the plan; a misstep that can result in project failure (Czuchry *et al.*, 2003).

The upshot is that a project is certainly in trouble when the CEPM has a work plan but does not understand the progress made to date and how much work is remaining (Bresnen *et al.*, 1984). When this happens, the project team is not utilized efficiently on the most critical activities. Ultimately, the project team members reach the end of the project and realize that they have much more work to copy with than anticipated, since earlier scheduled work will not have been completed (Czuchry *et al.*, 2003). The team may also discover that parts of the project require rework because earlier required steps were not completed (Moore *et al.*, 1999). There are various other reasons project failure and these include:

i. Project allocation prioritization. As the number of projects in an organization increases, the need for prioritization and allocation processes can become critically important (Darke *et al.*, 1998). If these processes are missing, the project failure rate increases because CEPMs do not have any reliable way to assure that the availability of the resources meet time and budget constraints.

ii. Multiple projects and portfolios. CEPMs responsible for multiple projects invariably need special tools to maximize the yield of their portfolios (Dulaimi *et al.*, 1999). These tools include techniques for assessing the business value that each project will yield (Dale *et al.,* 1990). If these projects are not assessed properly the CEPMs will be unable to properly prioritize projects nor will be able to allocate resources according to priorities and deadlines established.

iii. Team member motivation and conflict. CEPMs often find themselves with a team composed of people who have been borrowed from various departments. Team members may view the new project assigned as an additional burden they have to bear or another heaped on top of their regular tasks and duties. This makes motivating a project team a challenging task that can cause the failure of an entire project (Stipek *et al.,* 2002). A CEPM's interpersonal skills are used to make clear assignments, perform fair evaluations of work and to give performance feedback in ways that make the project a positive experience for people (Stipek *et al.*, 2002). Failure to handle any of these issues effectively can produce conflict within the project team (Moore *et al.*, 1999). The team members can also have conflict with other people with whom they have worked with during the course of the project (Alderman *et al.,* 1999).

In the vast majority of cases, CEPMs are the architect of their own failure. Surveys in published work points out that five primary reasons that CEPMs undermine their own success:

- Poor interpersonal skills are the single biggest reason for general project failure, particularly in the early and middle stages of a manager's career (Brown *et al.,* 2003). For some, the problem is getting along with subordinates. In most cases, when managers cannot inspire and win loyalty of subordinates, it is because they are not good listeners, do not give and take criticism well and/or view conflict as something bad, instead of something inevitable that has to be handled.
- Failure to adapt. CEPMs who are at one point very successful, and now clings to an unsuccessful management style or business strategy long after it

stops producing results (Phua *et al.*, 2004). This rigidity and lack of flexibility is ultimately a self-defeating style (Chan *et al.*, 2004).

- Selfish protection. Some CEPMs have an overriding concern for how much credit they are getting, how much money they are making and how fast they are moving up the ladder (Proverbs *et al.*, 1999). It is incredibly wearing when someone is constantly demanding recognition and incapable of any selfless acts towards others (Salamon *et al.*, 1998). Just as a successful business must pay attention to its customers, a successful CEPM must pay attention to subordinates (Svensson *et al.*, 2003). It is necessary to be a real team player and less selfish (Phua *et al.*, 2004).
- Inability to act. CEPMs who hesitate to put themselves on the line and act will eventually jeopardize their careers (Stuckenbruck *et al.*, 1976 and Mikkelsen *et al.*, 1983). The poor CEPM will study every minute detail before any action is made to avoid risk (Sawczuk *et al.*, 1996). As Dr Martin Luther King once said paralysis by analysis (Fava *et al.*, 1992).
- Inability to rebound. Making decisions, taking risks and at times failing is all part of a natural management cycle. However, it is absolutely critical to be able to bounce back after a failure. Indeed, Sir Winston Churchill once said that successes is the ability to move from one failure to anther without any loss of enthusiasm. When a CEPM becomes defensive or tries to blame others, there is generally a lack of natural ability (Walker *et al.*, 2002).

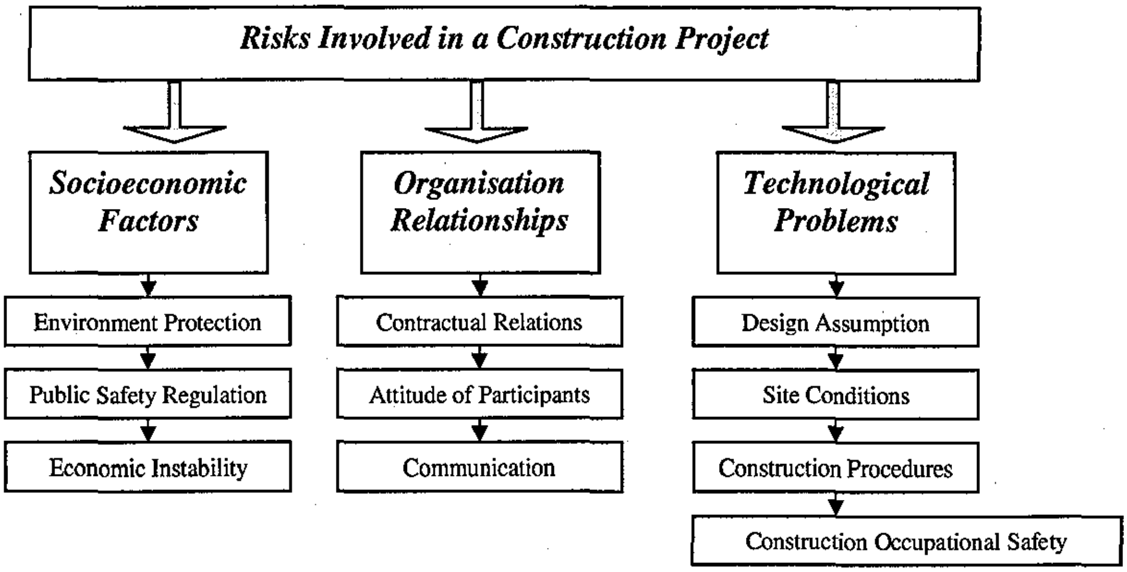
3.6 EFFECTS OF PROJECT RISKS ON ORGANIZATION

The uncertainty in managing a construction project comes from many sources and often involves many participants in the project (Miller *et al.*, 2001). Since each participant tries to minimize its own risk, the conflicts among various participants can be detrimental to the project (Akinsola *et al.*, 1997). Only the client has the power to moderate such conflicts as the client alone holds the key to risk assignment through proper contractual relations with other participants (Webster *et al.*, 1999). Failure to recognize this responsibility by the client often leads to undesirable results (Moolin *et al.*, 1981 and Akintoye *et al.*, 1995).

In approaching the problem of uncertainty, it is important to recognize that incentives must be provided if any of the participants are expected to take a great risk (Armandi *et al.*, 2003). However, society's perception of the potential liabilities of the participant can affect the attitude of risk-taking for all participants (Baloi *et al.*, 2003). When a claim is made against one of the participants, it is difficult for the public to know whether a fraud has been committed, or simply that an accident has occurred (Briscoe *et al.*, 2000). Risks in construction projects may be classified in a number of ways (Appolonia *et al.*, 1979 and Runeson *et al.*, 1997), and one classification is as follows: Socioèconomic factors; environment protection, public regulation and economic instability.

Determining which risks are likely to affect a project and documenting the characterises of each, constitute a fundamental step in project risk management processes. By identifying and prioritising potential risk sources at the outset of a project development, pitfalls could be avoided thereby eliminating or minimising the consequences of adverse events. Figure 3.5 presents the main three elements of the risks in construction projects.

Figure 3.5 Risks In Construction Projects.



3.7 DEVELOPING A WORK SYSTEM FOR MANAGEMENT

The CEPM must take the most effective approach to control the project (Wideman *et al.*, 1989). Two choices are commonly used in this field (Atkinson *et al.*, 1999). The *aggressive* approach is usually used by the CEPM who understands the estimate and how it applies to the contract drawings (and specifications) (Blenkinsopp *et al.*, 2004). Armed with this knowledge, the CEPM works to reach the goals, implementing objectives systematically. The success of each working process can be measured against the schedule, the intended plan (Darke *et al.*, 1998). On the other hand, the *docile* approach has the CEPM reacting to daily occurrences, often spending money, above the estimate, to correct the circumstances that may have been avoided through proper planning (Dulaimi *et al.*, 1999).

A manageable system is one that establishes a timetable, guaranteeing performance of tasks, sequenced to meet the time limitation of the contract (Elsby *et al.*, 1981). The efficiency of the project must be measured in order to evaluate the success of the established goals (George *et al.*, 1994 and Atkin *et al.*, 1995). From the estimate, the CEPM delineates the *when* and *how much* of each resource needed to perform each task (Helper *et al.*, 1991). The CEPM must then ensure that each resource is provided within the correct task at the desired time (Orlikowski *et al.*, 1997 and Blenkinsopp *et al.*, 2004). Resource management should be shared with the project superintendent validating the manpower demands as anticipated by the estimate (Kicklighter *et al.*, 1995).

3.8 MATERIALS MANAGEMENT

Materials management is an important element in project planning and control (Koushki *et al.*, 2004). Generally, materials represent a major expense in construction, so minimizing procurement or purchase costs presents important opportunities for reducing overall costs (Mahdjoubi *et al.*, 2001). At the same time, poor materials management can also result in increased costs during construction (Larson *et al.*, 2003). First, if materials are purchased early, capital may be tied up and interest charges incurred on the excess inventory of materials (Stukhart *et al.*, 1987). Even worse, materials may deteriorate during storage or be stolen unless special care is taken; this adding to the cost (Koushki *et al.*, 2004). For example, cement must be stored in a waterproof location, because cement should be kept dry during storage in order to avoid air-setting (Pettersson *et al.*, 1994). Second, delays and extra expenses may be incurred if materials required for particular activities are not available (Koushki *et al.*, 2004). Accordingly, ensuring a timely flow of material is an important concern of CEPM (Stukhart *et al.*, 1987).

Materials management is not just a concern during the monitoring stage in which construction is taking place (Koushki *et al.*, 2004 and Ondari *et al.*, 1999). Decisions about material procurement may also be required during the initial planning and scheduling stages (Suchman *et al.*, 1987). For example, activities can be inserted in the project schedule to represent purchasing of major items such as elevators for buildings (Atkinson *et al.*, 1999). The availability of the materials may greatly influence the schedule on fast track projects and therefore, sufficient time for obtaining the necessary materials must be allowed (Lewis *et al.*, 1997). In some case, more expensive suppliers may be employed to save time (Yuthas *et al.*, 1998 and Battikha *et al.*, 1998).

3.9 SITE MATERIAL MANAGEMENT

Site materials management for example, extends beyond the functions of receiving, storing and issuing materials (Elegant *et al.*, 1992 and Omachonu *et al.*, 1994). It is affected by other elements of project management including engineering, procurement, expediting and quality control (Wideman *et al.*, 1989). It is important, therefore, that site functions are well planned and executed and that they be an orderly and logical continuation of an overall materials plan (Holroyd *et al.*, 1999). Site materials management functions are detailed functions that increase in complexity with the size of the project and may require specialised skills and talents (Bell *et al.*, 1986).

The large volumes of structural, piping and electrical materials that must be dealt with on large industrial projects make the use of computer management systems (Battikha *et al.*, 2002b and Zhang *et al.*, 2005). The ability of those systems to catalogue, sort and combine materials by drawing, systems, areas or other category. Allocating materials to a specific work plan can be a significant aid to craft planning. Full benefits are realised however, only if the systems put in place on the job site are fully understood, accepted and utilised by the craft operatives of specialist sub contractors (Darke *et al.*, 1998). This interface is the key to achieving the substantial cost savings that are possible through the use of this technology (Griffith *et al.*, 2000).

Receiving, storing, controlling and distributing of materials during construction works site are functions which appear routine on the surface but can significantly effect project cost and schedule (Akintoye *et al.*, 1995). Lost, damaged, misplaced or improperly stored and maintained equipment and material can result in expensive delays and distribution (Koushki *et al.*, 2004). These and many other material problems can be reduced or eliminated with the proper planning and implementation of the necessary materials management systems and procedures (Willis *et al.*, 1995).

3.10 INTERPERSONAL BEHAVIOUR IN PROJECT ORGANIZATION

While a successful CEPM must be a good leader, other members of the project team must also learn to work together, whether they are assembled from different divisions of the same organization or even from different organizations (Woodward *et al.,* 1997). A problem of interaction may arise initially when the team members are unfamiliar with their own roles in the construction project team, particularly for large and complex construction projects (Connor *et al.,* 1985). These problems must be resolved quickly in order to develop an effective, functioning team (Lee *et al.*, 2002).

Many of the major issues occurring on construction projects require effective interventions by individuals, groups and organizations (Langford *et al.*, 1991). The fundamental challenge is to enhance communication among individuals, groups and organizations so that obstacles in the way of improving interpersonal relations may be removed (Larson *et al.,* 2003). Some behaviour science concepts are helpful in overcoming communication difficulties that block cooperation and coordination (Ziyal *et al,.* 1995). In very large construction projects, professional behaviour scientists may be necessary in diagnosing the problems and advising the personnel working on the construction project (Carmichael *et al.,* 1995). The power of the organization should be used judiciously in resolving conflict (Lee *et al.,* 1997).

The major symptoms of interpersonal behaviour problems can be detected by experienced observers and they are often the sources of serious communication difficulties among participants in a project (Culpan *et al.,* 2002). For example, members of a construction project team may avoid each other and withdraw from active interactions about differences that need to be dealt with (Wade *et al.,* 2004). They may attempt to criticize and blame other individuals or groups when things go wrong (Sawczuk *et al.,* 1996). They may resent suggestions for improvement and become defensive to minimize culpability rather than take the initiative to maximize achievements (Baloi *et al.*, 2003). However, all theses actions are detrimental to the construction project organization (Dulaimi *et al.*, 1999).

3.11 LABOUR RELATIONSHIPS DURING A CONSTRUCTION PROJECT

The market demand in construction fluctuates greatly, often within short periods and uneven distributions among geographical regions (Blain *et al.*, 1987). Even when the volume of construction is relatively steady, some types of work may decline in importance while other types gain (Au *et al.*, 1985 and Blain *et al.*, 1987). Within an unstable economic environment, construction employers place great value on flexibility in hiring and laying off workers as their volumes of work wax and wane (Mustapha *et al.*, 1996). On the other hand, construction workers sense their insecurity under such circumstances and attempt to limit the impacts of changing economic conditions through labour organizations (Abeysinhe *et al.*, 1999).

There are many crafts in construction labour forces but most contractors hire from only a few of these crafts to satisfy their specialized needs. However, because of the peculiar characteristics of employment conditions, employers and workers are placed in a more intimate relationship than in many other industries (Allen *et al.*, 1988, Xiao *et al.*, 2003, Allen *et al.*, 1988 and Chan *et al.*, 2004).

3.12 SUMMARY

Infrastructure and heavy construction includes projects such as highways, mass transit system, tunnels, bridges, pipelines, drainage system and sewage treatment plants. Most of these civil engineering projects need high quality of supervisor in order to deliver high quality civil engineering project where skills for the CEPM is does make lots of different.

This chapter has considered and focused widely on classifying the capability of construction and civil engineering managers CEPM in the UK. The efficient and effective CEPM will have a high level of performance and will ensure that construction and civil engineering projects are a success as measured by means of quality and saving time, cost etc.

This chapter has considered the essential duties performed by the CEPM. Also CEPM's responsibilities have been mentioned. Essential skills for the CEPM have also been included in this chapter. Other important issues that are relative to the CEPM duties such as materials management and labour relationships during the construction works have also been discussed.

CHAPTER _4_
Technology Application

4.0 INTRODUCTION

Research has been defined as being a methodological procedure that is used to satisfying human curiosity (Beach *et al.*, 1992). Research is considered to be a voyage of discovery, contributing to knowledge and evoking new learning (Kumar *et al.*, 1999). Inherent within any good quality research is a desire to conduct systematic enquiry, looking for and examining relationships, comparisons, predictions and generalisations (Wing *et al.*, 1998). A prerequisite for performing research is the development and usage of a robust and scientifically correct methodology (Krebs *et al.*, 1999). The objectives of the methodology are to improve the procedures and approaches employed in the conduct of scientific research (Ackoff *et al.*, 1962). Here, methodology refers to the procedure of selecting appropriate techniques for a research project, that is, to evaluate alternative courses of scientific action (Prasad *et al.*, 1997). This chapter will discuss the aspects of research disciplines, strategies and methods prior to developing a suitable strategy with which to investigate the factors and variables that impact upon a civil engineering project manager's competence. Essentially an iterative methodological approach is proposed which consist of the following five key stages, namely: i) literature review; ii) questionnaire design; iii) sample selection; iv) the application of techniques used to achieve the stated objectives; and v) validation.

4.1 RESEARCH STRATEGIES

There are broadly two different research strategies, namely qualitative and quantitative (Fellows *et al.*, 1997). Qualitative research works with few variables in many cases, whereas quantitative research relies on a few cases and many variables (Creswell *et al.*, 1998, Hassiss *et al.*, 1999 and Gardy *et al.*, 1998). Unlike qualitative research, all quantitative research requires the development of a hypothesis before research can begin (Kaplan et al., 1988, Alavi *et al.*, 1992 and Morgan *et al.*, 1998). This study uses both techniques in combination.

4.1.1 Qualitative Research

Qualitative research is typically performed in a natural setting (field focused) and is designed to provide the researcher with the perspective of target audience members through immersion in culture or situation and direct interaction with people under study (Creswell *et al.*, 1998). The qualitative approach seeks to gain insight and understanding of people's perceptions of their surrounding environment (Fellows *et al.*, 1997 and Gummesson *et al.*, 2000). Creswell (1998) states that:

Qualitative research is an inquiry process of understanding based on methodological traditions of inquiry that explore a social or human problem.

Qualitative research often commences with a fundamental research question of how or what is going on under a given set of circumstances. The information gathered in qualitative research can be divided into exploratory and/or attitudinal research (Naoum *et al.*, 1998). Exploratory research is used when a limited amount of knowledge about a topic is known, for example, diagnosing a situation, screening alternatives and discovering new ideas (Naoum *et al.*, 1998). One typical feature of exploratory research to find a research question and not a hypothesis (Creswell *et al.*, 1998). The results from this question is a description of what people have said or what has been observed (Prasad *et al.*, 1997). Attitudinal research however is subjectively used to evaluate perceptions and attitudes of a person or group towards a particular item (Naoum *et al.*, 1998). The objective of qualitative research is to collect information and data in order to gain an understanding so that an explanation can be made and theories created (Neuman *et al.*, 2000). Thus, qualitative research can be precursor research (Fellows *et al.*, 1997).

4.1.2 Quantitative Research

Creswell (1998) defines quantitative research as an enquiry into social or human problems, based on testing a hypothesis or a theory composed of variables, measured with numbers and analysised with statistical procedures. The overall objective is to determine whether the hypothesis or theory holds true (Kaplan *et al.*, 1988). Thus, the approach is to gather factual data and to study relationships between facts and identify and examine relationships according with theories and previously published research findings (Fellow *et al.*, 1997). Grady (1998) defines quantitative research as a set of methods that are used to answer questions that ask why. In contrast to qualitative research, quantitative research tends to look for comparisons of groups or relationships between variables and attempts to establish cause and effect (Denzin *et al.*, 1994). In quantitative research, the hypothesis, research question and objective(s) can be better understood when they are grounded in a theoretical framework (Naoum *et al.*, 1998). Quantitative research is often chosen when a researcher wants to establish or dismiss a particular theory or hypothesis (Miles *et al.*,1984). Quantitative research focuses on measurement and counting, attempting to categorize and summarize using numbers and/or labels (Neuman *et al.*, 2000).

Qualitative research aims more at thoroughly describing a situation or explaining reasons for a problem or circumstance (Greenfield *et al.*, 1996). It is typically thorough and provides an in-depth understanding of a situation or group of people but does not attempt to quantify results (Morgan *et al.*, 1998). Often, both quantitative and qualitative approaches are used in a research study (Kaplan *et al.*, 1994., Harvey *et al.*, 1995., and Fellows *et al.*, 1997). Indeed, for this research work a combination of techniques will be employed in order to maximise the benefit of the research output.

4.2 RESEARCH METHOD(S)

Research methods are simply a scientific, methodical way of finding answers to questions (Cash *et al.*, 1989). The type of research method used is based on the purpose(s) of the study (Neuman *et al.*, 2000). Applying an appropriate research method(s) for a particular research project is dependent on the problem being studied or the questions being answered (Sekaran *et al.*, 1992 and Mingers *et al.*, 2001). Other considerations include the nature of the investigation and the type of information that is available or required (Cryer *et al.*, 1996 and Naoum *et al.*, 1998). Wing (1998) argued that:

The research method used should be appropriate to the objectives of the research and the needs of the particular stage reached and hence, the type of knowledge to be discovered.

When these choices have been made it is appropriate to carefully consider the techniques for collecting data (Seymour *et al.*, 1997; and Naoum *et al.*, 1998). The wider research community does not however always approve of the use of a particular method, even if the method is appropriate for the intended study (Yin *et al.*, 1994). Approved methods are rooted in the philosophical supremacy of research; where philosophical supremacy refers to the refusal of scientists to accept any knowledge founded in any alternative philosophy or science other than their own (Baskerville *et al.*, 1996). The reason for rising the issue of philosophical supremacy is discussed here because the method employed must be well argued and substantiated for it to be accepted. The previously stated research questions and research objectives of this study indirectly point towards more specific methods for data collection (Baskerville *et al.*, 1996). Some of these methods will now be briefly discussed as a precursor to choosing an approach for this study.

4.2.1 Evaluated Research Methods

The most commonly used research methods in construction research are surveys, cases studies, ethnographic, experiment and action research (Altmann *et al.*, 1974 and Fellows *et al.*, 1997). The choice of method to be used is dependent upon the research problem being studied (Greenfield *et al.*, 1996). However, these methods are not mutually exclusive and many researchers choose to use a combination of approaches (Gable *et al.*, 1994).

4.2.2 Surveys

Survey research essentially collects information from individuals, about themselves or about their social units, using various techniques ranging from highly structured formal questionnaires to unstructed informed interviews (Forza *et al.*, 2002). Surveys are often used to gather data from a relatively large number of respondents within a limited time frame (Naoum *et al.*, 1998) and surveys are perhaps one of the dominant forms of data collection in the social sciences (Moser *et al.*, 1979; and

Forza *et al.*, 2002). Within survey research a distinction is often made between descriptive, analytical and exploratory survey research (Sieber *et al.*, 1979 Grimshaw *et al.*, 1994; and Kalton *et al.*, 1995):

- Exploratory survey means, just as it implies, to explore a new phenomenon in the early stages of the research process. Analytical research however (or theory testing) takes place when knowledge of a phenomenon has been articulated in theoretical form using well-defined concepts, models and propositions (Forza *et al.*, 2002). An analytical survey is appropriate for quantifiable data requiring statistical interpretation to gain its meaning (Beach *et al.*, 1992).
- A descriptive survey is aimed at understanding the relevance of particular occurrence(s) and seeks to describe the distribution of a result in a population (Forza *et al.*, 2002). Survey research asks questions and is a method which forces individuals to formulate opinions about these questions (Rudestam *et al.*, 1992; and Greenfield *et al.*, 1996).

4.2.3 Case Studies

A case study is a traditional research method and one of several ways of performing research in social and management science (Pheng *et al.*, 2001). Yin (1994) defines a case study as:

an empirical inquiry that investigates a contemporary occurrence within real life context, especially when the boundaries between phenomenon and context are not clearly evident.

Thus, the objective is to immerse oneself in the situation and gain a holistic understanding of a phenomenon in its natural setting (a person, a group of people and organisation or a particular project) (Benbasat *et al.*, 1987 and Chen *et al.*, 1998). Normally, only a few cases are studied and due to this, the case study research will typically try to uncover more variables of interest than data points (so called richness of detail) (Cavaye *et al.*, 1996). This latter point may be considered to be the strength of case study research, making it possible to uncover causal relationships (Smith *et al.*, 2004).

Case studies can be divided into three types of categories, i.e. exploratory, descriptive and explanatory (Darke *et al.*, 1998). Case studies employ a variety of data collection methods but usually they employ interviews of key factors in the subject of the study (Fellows *et al.*, 1997). Descriptive cases studies relate to corresponding survey approaches except that they are applied on detailed case(s). Exploratory case studies however, try to explain causality (proposition testing) and aim to show relationships among studied items (Naoum *et al.*, 1998). Case studies can be performed in combination with both ethnographic research and action research (Fellow *et al.*, 1997).

4.2.4 Ethnographic Research

Ethnographic research originates from social sciences research work conducted by early 20th century anthropologists and their studies of comparative cultures (Créswell *et al.*, 1998). Ethnography is a form of research that focuses upon applying insights from social and cultural anthropology to the direct observations of socio-cultural phenomena (Avison *et al.*, 1995). The term ethnography originates from the term ethnocentrism that refers to the tendency of people in most cultures to think of their own culture as the most sensible (Harvey *et al.*, 1995). Good ethnographic research makes sense of beliefs, values and practices of natives in a closed society that were considered as absurd in other societies (Prasad *et al.*, 1997). Thus, a goal of ethnographic research is to improve the understanding of human thought and action through interpretation of human actions in context (Schultze *et al.*, 2000). The researcher must therefore go native by becoming part of the community under study to observe behaviour and statements in order to gain insight into what, how and why the patterns occur (Suchman *et al.*, 1987). Ethnography is a research method well suited to providing researchers with rich insights into the beliefs and values of human, social and organisational aspects of a socio-cultural phenomenon (Harvey *et al.*, 1995). The result of the method is, however, difficult to determine due to the uncertainty of the influence caused by the presence of the researcher and existence of the research project (Fellows *et al.*, 1997).

4.2.5 Experimental Research

Experimental research is the only method that can claim cause-and-effect and is associated with the traditional scientific method (Ackoff *et al.*, 1962). An experiment intentionally discovers a phenomenon from its context, so that attention can be focused on a few variables only (Baccarini *et al.*, 2001). Typically, the context is controlled by a laboratory environment (Yin *et al.*, 1994). In experimental research, the researcher deliberately manipulates an independent variable (cause) to see if it creates a change in the dependent variable (effect) (Krebs *et al.*, 1999). Experiments are best suited to bound problems or issues in which the variables involved are known, or at least hypothesised with some degree of confidence (Fellows *et al.*, 1997). Experimental research is divided into true experiments, quasi-experiments and pre-experimental design (Alavi *et al.*, 1992). True experiments are those that use a random assignment of subjects, whereas those that do not are called quasi-experiments (applied when using human subjects) (Harvey *et al.*, 1995). Pre-experimental design is used when little control of the factors that could affect the outcome of a study is possible (no use of another group for comparison) (Kaplan *et al.*, 1994). Isaac and Michael (1981) identified the purpose of experimental research as investigating the:

Possible cause-and-effect relationships by exposing one or more experimental groups to one or more treatment conditions and comparing the results to one or more control groups not receiving the treatment (Sekaran et al., 1992).

When these experiments are conducted in dynamic social environments and not in an isolated laboratory environment, it becomes increasingly difficult to claim causality (Alavi *et al.*, 1992). A well-know example is the Hawthorne Experiment, which intended to investigate the relationship between illumination and productivity at the Western Electric Hawthorne Works (Mayo *et al.*, 1949). The Hawthorne Experiment showed how difficult it is to claim causality in dynamic environments (Baccarini *et al.*, 2001). Due to this known limitation and also the consequence of the broad and comprehensive research questions, which preclude the use of a controlled, bound study to examine the effect of changes in a dependent variable, the choice of an experimental approach was rejected (Brown *et al.*, 1995).

4.2.6 Action Research

Action research is a research method that attempts to achieve both research and practical objectives by linking the concepts of theory and practical but also thinking and doing (Baskerville *et al.*, 1996). One distinguishing feature, un-like the methods of objectivist science therefore, is the active and deliberate self-involvement of the researcher in the context of the investigation (Altrichter *et al.*, 2002). Argyris and Schon (1989) state that action research:

Builds descriptions and theories within the practice context itself and tests them through intervention experiments – that is, through experiments that bear the double burden of testing hypothesis and effecting some (putatively) desirable change in the situation.

Action research has dual aims, which are highly interlinked (Rapoport *et al.*, 1970; and Swann *et al.*, 2002). One is to bring improvements through making changes in a problematic situation inside an organisation and the other is to generate new knowledge and new insights as a result of those activities (Altrichter *et al.*, 2002).

In action research the researcher reviews the current situation, identifies the problem, gets involved in introducing some changes to improve the situation and in contrast to survey and case study research where the researcher tends not to interfere with that which is being studied, possibly, evaluates the effect of the changes (Naoum *et al.*, 1998). Action research receives critique, which requires:

Action researchers to defend their method against the challenge that, this is nothing but consultancy! (Baskerville et al., 1996).

4.3 SELECTION OF AN APPROPRIATE RESEARCH METHOD

Based on the earlier paragraphs of this chapter an appropriate research method was chosen. The choice of method depended on a judgement as to which method or technique(s) would best obtain the information needed in order to achieve the objectives of the study (Naoum *et al.*, 1998). The research method should be appropriate to objectives of the research and needs of the particular stage reached, hence, and type of knowledge to be discovered. Different approaches serve different functions in the knowledge discovery process (Wing *et al.*, 1998). Therefore, consideration of both a qualitative and a quantitative approaches was perceived to be equally useful for this research investigation.

Each research method described in the earlier paragraphs has its benefits and some of these methods are applicable, to some extent, to the shared objectives. An analytical survey is very much appropriate to this research particularly when quantifiable data requires statistical interpretation to gain its meaning (Beach *et al.*, 1992). At the same time, and for example, a descriptive survey is appropriate when trying to understand the relevance occurrence and describing the distribution of the results and how these relate to a population under study (Forza *et al.*, 2002). Indeed, a combination of methods is often appropriate to make use of their different strengths (Moser *et al.*, 1979). Descriptive and analytical cases studies relate to the corresponding survey approaches except that they are applied on detailed(s).

Another determining factor for choosing an analytical survey research design, was due to the fact that this method that has been extensively and successfully used in construction project management science (Benson et al., 1926, Kalton *et al.*, 1977, Moser *et al.*, 1979, Cash *et al.*, 1989, Vaus *et al.*, 1993, Gable *et al.*, 1994, Alreck *et al.*, 1995 and Forza *et al.*, 2002). Thus, analytical survey research designs allow researchers to develop knowledge (Gable *et al.*, 1994). Analytical research however takes place when knowledge of phenomenon has been articulated in theoretical form using well-defined concepts, models and propositions (Forza *et al.*, 2002).

4.3.1 The Strengths of the Analytical Survey.

The main strengths of an analytical survey are that:

1. They are relatively inexpensive to create and administrate (especially self-administered surveys).
2. They are useful in describing the characteristics of a large population. No other method of observation can provide this general capability.

3. They can be administered from remote locations using mail, email and telephone.
4. Very large samples are feasible, making the results statistically significant even when analyzing multiple variables.
5. Many questions can be asked about a given topic giving considerable flexibility to the analysis.
6. There is flexibility at the creation phase in deciding how the questions will be administered: as face-to-face interviews, by telephone, as group administered written or oral survey or by electronic means.
7. The use of standardized questions make measurement more precise by enforcing uniform definitions upon the participants.
8. Standardization ensures that similar data can be collected from groups then interpreted comparatively (between-groups or within a group).
9. Usually, high reliability is easy to obtain by presenting all subjects with a standardized stimulus, observer subjectivity is general eliminated.

The main tool used within an analytical survey for data collection is a questionnaire (Kirakowski *et al.*, 1997). A questionnaire survey is used as it can test the relationships that exist between a CEPM's personal traits and characteristics and project performance.

Historically, questionnaires are very cost effective when compared to face-to-face interviews (Kirakowski *et al.*, 1997). This is especially true for studies involving large sample size and large geographic areas (Liefeld *et al.*, 1988). Written questionnaires become even more cost effective as the number of research questions increases and also, questionnaires are less intrusive than telephone or face-to-face survey (Kalton *et al.*, 1995). When respondents receive a questionnaire in the mail, they are free to complete questionnaires in their own time and unlike other research methods, the respondent is not unduly interrupted by the research instrument (Kirakowski *et al.*, 1997).

Questionnaires survey are also familiar to most people. Almost everyone in the developed world has some experience of completing questionnaires and they generally do not make people apprehensive (Kirakowski *et al.*, 1997). Written questionnaires reduce interviewer bias because there is uniform question presentation (Jahoda *et al.*, 1962). Unlike in-person interviewing, there are no verbal or visual clues to influence a respondent to answer in a particular way. Many investigators have reported that interviewer voice inflections and mannerisms can bias responses (Barath *et al.*, 1976; Benson *et al.*, 1926; Boyd *et al.*, 1965; Collins *et al.*, 1970; Dohrenwend *et al.*, 1968; Franzen *et al.*, 1945). Finally, questionnaires are easy to analyse because data entry and tabulation for nearly all surveys can be easily done with many computer software packages (Kock *et al.*, 1997).

4.4 APPLIED RESEARCH DESIGN

Today the survey is used most often to describe a method of gathering information from a sample of individuals or subjects within a given population (Moser *et al.*, 1979 and Abdul-Aziz *et al.*, 2002). Generally, the sample is not selected haphazardly or only from persons who volunteer to participate (Moser *et al.*, 1979). It is scientifically chosen so that each person in the population will have a measurable chance of selection (Altmann *et al.*, 1974). Therefore, the results can be reliably used to draw inference about a population under study (Oppenheim *et al.*, 1992). Information is collected by means of standardized procedures so that every individual is asked the same questions in more or less the same way (Krebs *et al.*, 1999). The survey's intent is not to describe the particular individuals who are part of the sample but to obtain a composite profile of the population (Martin *et al.*, 1993).

Surveys also represent one of the most common types of quantitative, social science research (Moser *et al.*, 1979). In survey research, the researcher selects a sample of respondents from a population and administers a standardized questionnaire to them (Alreck *et al.*, 1995). The questionnaire, or survey, is often a written document and can be completed online, completing either a fact-to-face or telephone interview (Grimshaw *et al.*, 1994). More often, questionnaires are posted to sample respondents who then complete the survey and then post back the completed form to the researcher (Oppenheim *et al.*, 1992). Questionnaires are an effective method used to collect information regarding a sample's characteristics, experiences, qualification and opinions (Forza *et al.*, 2002). The findings from survey questionnaires can then be generalized to the larger population that the sample represents (Gall *et al.*, 1996). In this study, analytical survey questionnaires were used to elicit data regarding CEPM's characteristics (such as qualification, subject (background), experience in the field , ...etc) in order to classify the aptitude of construction and civil engineering managers in the U.K. However, analytical survey research is not without its problems (Kalton *et al.*, 1995). In order to discover these problems and resolve them before sending out the final questionnaires, a decision was made to carry out a pilot study to validate the robustness of questions posted and format of the purposed data collection instrument.

4.4.1 Statistic and Data Analysis Techniques

Today's competitive landscape makes the critical link between good decisions and success more important than ever (Hastie *et al.*, 2001). From corporations and government agencies to research institutes and universities, increasingly organisations are turning to statistical analysis to guide decision-making processes (Leitnaker *et al.*, 1995). Statistics is the science of obtaining, synthesizing, predicting, and drawing inferences from data (Dale *et al.*, 1990). It involves collecting, organizing and interpreting numerical and non numerical facts (Leitnaker *et al.*, 1995 and (Kalton *et al.*, 1977). The role of statistics is to summarise, to simplify and eventually to explain the behaviour of the data. Using optimal statistical techniques can provide new information that improves processes, drives development and revenues and helps the retain valued and satisfied customers (Moore *et al.*, 1993 and Johnson *et al.*, 1998).

The method of collection and study of data is very important. Knowledge of probability and statistical methods are also useful for informatics specialists in various fields such as data mining, knowledge discovery, neural network, fuzzy system and so on (Forza *et al.*, 2002).

It is clearly not possible to develop a new mathematical models for each combination of dependent and independent variables (Chia *et al.*, 1995). Hence, there are standard mathematical models available whose properties are well known, thus making the computational task more simplistic (Woodruff *et al.*, 1971).

However, by using standard models, instead of deriving the best mathematical models for variables in the dataset, the process is reversed (Fisher *et al.*, 1988). As a result, the variables may not fit into a standard model. To improve the fit, variables are often transformed resulting in summary indices that are not easily interpreted (Francisco *et al.*, 1977 and Gail *et al.*, 1996).

Statistics represents a body of knowledge which enables one to deal with quantitative data reflecting any degree of uncertainty (Davis *et al.*, 1986). At the same time, there are six basic aspects of applied statistics which have been mentioned by John (2002). These are:

1. type of data;
2. random variables;
3. models;
4. parameters;
5. sample statistics; and
6. characterization of chance occurrences.

From these various strategies and procedures inferential statistics can be developed (John *et al.*, 2002). At the same time, for creating the models, the modelling problem can be defined as estimating the relation between a set of predictor variables (X) and one or more response (Y):

$$Y = f(x) + \varepsilon \qquad \text{Eq. 4.1}$$

In which ε contains sampling and measurement errors. The function $f(x)$ is the conditional expectation

$$f(x_i, y_i) = ({}^{Y}\!/_{X}) \qquad \text{Eq. 4.1}$$

The conditional expectation can be estimated by an approximation on a certain dataset (x_i, y_i), $i = 1, ..., n$. The estimation of the above mentioned relationship can be achieved by deriving an equation that describes the social physical or chemical mechanisms defining the process under study. In this case, the overall form of the relationship is known and only values of some parameters have to be estimated. Where functional relations are not (yet) known, then these functions have to be approximated by an empirical model (Anderson *et al.*, 1984). Based on that, the first objective in the modelling procedure is to search for an appropriate class of functions in which the true function is expected to be a member. Next, a model is selected from the class of functions (Anderson *et al.*, 1994). The success of this procedure depends on the existence of a convenient class and correct choice of the class of functions. When a parametric regression model is used, one assumes that the true underlying function is a member of a very strict family of (parametric) models, whether these are linear or nonlinear (Deville *et al.*, 1992). Generally, the role of statistics is to summarise, to simplify and eventually to explain the behaviour of the data.

4.5 GENERAL CONCEPTS OF MULTIVARIATE DATA ANALYSIS

Multivariate analysis examines the statistical properties among three or more variables across multiple subjects (in conjunction with one anther) (George *et al.*, 1984). The analyst seeks to discover relationships that could not otherwise be discovered by employing multiple bivariate tests (Johnson *et al.*, 1989). Whereas, univariate analysis, on the other hand, concerns examining the statistical properties of a single variable (mean, median, mode, etc.). Finally, Bivariate analysis, examines the statistical properties and relationship between two variables in conjunction with one another (Johnson *et al.*, 1998).

Within multivariate analysis there are several well established techniques that could have been used to study the research question posed by this research work; these are:

- Multiple Regression;
- Multivariate Discriminate Analysis (MDA);
- Multivariate Analysis of Variance (MANOVA);
- Canonical Correlation;
- Linear Probability Models (LOGIT and PROBIT);
- Conjoint Analysis;
- Structural Equation Modelling (SEMs);
- Factor Analysis (FA);
- Cluster Analysis (CA);

- Multidimensional Scaling (MS); and
- Correspondence Analysis.

In order to understand multivariate analysis, it is important to first understand some of terminology. The propose of the analysis is to find the best combination of weights that can describe a pattern trend (Gail *et al.*, 1996 and Anderson *et al.*, 1984). Nonmetric data refers to data that are either qualitative or categorical in nature. Metric data refers to data that are quantitative, and interval or ratio in nature. The form of data refers to whether the data are nonmetric or metric. The quality of data refers to how normally distributed the data are (Hastie *et al.*, 2001).

Multiple regression is the most commonly utilized multivariate technique (Wetherill *et al.*, 1986). It examines the relationship between a single metric dependent variable and two or more metric independent variables. The technique relies upon determining the linear relationship with the lowest sum of squared variance; therefore, assumptions of normality, linearity and equal variance are carefully observed (Weslowsky *et al.*, 1976 and Cheng *et al.*, 2001).

4.6 MULTIVARIATE DISCRIMINANT ANALYSIS

Discriminate analysis was first introduced by Sir Ronald Fisher 1925 and represents a statistical technique designed to distinguish among several mutually exclusive groups based upon linear combinations of the independent, sometimes called predictor, variables (Johnson *et al.*, 1998). Discriminate analysis is a statistical technique which allows the differences between two or more groups of objects (with respect to several variables) to be studied simultaneously (Wetherill *et al.*, 1986). As in real life, there may be a number of factors ascribing the outcomes of a problem in the social, behavioural and biological sciences (Johnson *et al.*, 1982). The contributions and the identification of the variables to the outcome is the information that most researchers look for (James *et al.*, 1985).

Among multivariate statistical analysis techniques, Multivariate Discriminate Analysis (MDA) is concerned with separating distinct sets of objects (or observations) and with allocating new objects to previously defined groups. MDA tries to find the combination of variables that best predicts the category or group to which a case(s) belongs. The group identification must be known for each case used in the analysis. The combination of predictor variables is called a classification function and this function can then be used to classify new whose group membership is unknown. MDA deals with several variables simultaneously. It has proved to be successful in diverse fields such as medicine, sociology, business, finance, economics, education, biology, psychology and other scientific areas. Discriminate analysis is used to classify an observation into one of several groupings dependent upon the observation's individual characteristics. In this sense, discriminate analysis is concerned with allocating an individual to one of several groups on the basis of a number of measurements on the individual. It is used primarily to classify and /or predict in problems where the dependent variable appears in qualitative form.

The purpose of discriminate analysis is to correctly classify observations or people into homogenous groups. The independent variables must be metric and must have a high degree of normality. Discriminate analysis builds a linear discriminate function, which can then be used to classify the observations. The overall fit is assessed by looking at the degree to which the group means differ (Wilkes Lambda or D2) and how well the model classifies. To determine which variables have the most impact on the discriminate function, it is possible to look at partial F values. The higher the partial F, the more impact that variable has on the discriminate function. For example, with two groups, it is possible to derive one discriminate function that maximizes the ratio of between to within groups sums of squares (Weslowsky *et al.*, 1976). Where there are three groups, two discriminate functions can be calculated. The first function, as in the two groups cases, has the largest ratio of between groups to within groups sums of squares (Cheng *et al.*, 2001). The second function is uncorrelated with the first and has the next largest ratio. Generally, if there are k groups, (k-1) discriminate functions can be computed. Groups are all uncorrelated with each other and maximize the ratio of between groups to within groups sums of squares, subject to the constraints of being uncorrelated (Bosnjak *et al.*, 2001).

Basic purpose of discriminate analysis is to estimate the relationship between a single categorical dependent variable and a set of quantitative independent variables (Bowker *et al.*, 1972).

Discriminate analysis has widespread application in situations where the primary objective is identifying the group to which an object (e.g. person, firm or product) belongs (Davis *et al.*, 1986). Potential applications include predicting the success or failure of a new product (Klecka *et al.*, 1980), deciding whether a student should be admitted to graduate school (Press *et al.*, 1978), classifying students as to vocational interests (Fava *et al.*, 1992), determining what category of credit risk a person falls into or predicting whether a firm will be success or not.

4.7 ESTIMATING A DISCRIMINATE MODEL

By utilizing the Statistical Package for the Social Sciences (SPSS), an analyst can employ two methods for estimating a discriminate model, using either the simultaneous (analyst specified) or the sequential (forward, backward, stepwise) method (Anderson *et al.*, 1996). The criteria employed by SPSS for variable selection is the variable with the lowest Wilks Lambda coefficient (which is a ratio of Within Sum of Square-(WSS), to Total Sum of Square-(TSS), expressed as WSS/TSS) (Manly *et al.*, 1995; and SPSS 2004).

4.8 ASSESSING MODEL FIT IN MDA

One measure of fit is known as an Eigenvalue (Klecka *et al.*, 1980) and represents the model's ability to discriminate between groups. It is a ratio of Between the Sum of Squares (BSS) to Within Sum of Squares (WSS) (Overall *et al.*, 1972). A value of 0 represents no discrimination between the groups therefore, the large -the Eigenvalue, the large -the discriminatory power (Press *et al.*, 1978). A second measure of fit in MDA is the percentage of variance in dispersion between groups that can be explained by the model (Klecka *et al.*, 1980). A third measure of fit in MDA is Eta (aka canonical correlation) which represents the degree of overall correlation between all included Independent Variables (IVs) and Dependent

Variables (DVs). Values of Eta range from 0 to 1, with 1 being perfect. The Eta Coefficient is the square root of BSS/TSS.

Wilk's Lambda is the most common goodness of fit indicator for discriminate analysis. A ratio of WSS/TSS (Within Sum of Squares/Total Sum of Square), it is Chi-square distributed at $K-1$df (where k = number of parameters being estimated) (Romesburg *et al.*, 1984). Values closest to 0 are desired. As in most multivariate tests, a significant f value has the effect of rejecting the null hypothesis (Sharma *et al.*, 1996).

Another measure of fit available within MDA is a classification matrix (Tabachink *et al.*, 1989 and Frank *et al.*, 1998). By visually examining values on the diagonal (correct predictions) and values off diagonal (incorrect predictions), the analyst can successfully utilize the classification matrix (James *et al.*, 1985 and Duda *et al.*, 2001). The analyst can also establish a cutting score which determines which group a given case should be placed in (Lim *et al.*, 2000).

4.9 INTERPRETING THE FUNCTION

In order to interpret a discrimination function, the analyst must examine: estimated discriminate coefficients, standardised discriminate coefficients and discriminate loadings (Press *et al.*, 1978). An estimated (un-standardised) discriminate coefficient is examined for its sign. Each variable is represented in its original unit of measurement; therefore, no direct comparison is possible (Klecka *et al.*, 1980). A standardised discriminate coefficient is examined for sign and magnitude to determine the relative importance of each variable (Wetherill *et al.*, 1986). A discriminate loading is the representation of the degree of correlation between an independent variable and the discriminate scores produced by the model (Cheng *et al.*, 2001). The higher the absolute value of coefficient, the greater the discriminatory impact of the independent variable on the dependent variable (Aamodt *et al.*, 1995). In order to verify that the obtained weights are statistically significant, a one-way MANOVA is conducted where the sum of squares are used to calculate Wilk's Lambda (values close to 0 being desired) for each predictor variable; a finding of a significant f coefficient allows the analyst to reject the null hypothesis (Cooley *et al.*, 1971).

4.10 THREE GROUP DISCRIMINATE ANALYSIS

MDA generates a number of functions equal to the number of groups in the dependent variable minus one ($g-1$) (Klecka *et al.*, 1980). Therefore, when an analyst is performing MDA with three groups for example, the model that is generated will have two functions, requiring both independent and joint interpretation (George *et al.*, 1984). The model will estimate and fit two vectors (functions) to the three groups; one vector will typically be a good fit for, say, groups 1, and 3, but not group 2 (Wetherill *et al.*, 1986; and John *et al.*, 2002). The other vector will be a good fit for group 2, but not for group 1 and 3. Therefore, taken in combination with one another, both of the vectors explain the three groups better than either one would if interpreted alone (Anderson *et al.*, 1996). The statistical output from a discriminate analysis with more than two groups is comparable to a statistical output with one function except that multivariate sets of statistics are produced for each discriminate function (Gail *et al.*, 1996). These are:

i) Discriminate coefficients/weights;
ii) Standardised discriminate coefficients/weights;
iii) Group centroids;
iv) Structure coefficients/discriminate loadings;
v) Canonical correlation; and
vi) Wilk's Lambda.

The analysis must determine if each discriminate function is statistically significant. If only the first function is significant then interpretation is somewhat simple (Hastie *et al.*, 2001). However, if more than one function is significant, interpretation becomes problematic. Therefore, rotation of discriminate functions may be employed to aid in clarifying the position of each vector. In order to achieve maximum power between all categories of the dependent variable as well as determining the influence of each independent variable across multivariate function.

The use of a potency index aids the analyst in determining the relative influence of each independent variable across multivariate significant function (Hand *et al.*, 1981). The potency index is a composite measure derived from each variable's rotated discriminate loading and is a percentage of explained variance associated with each function (Tung *et al.*, 1985; and Lim *et al.*, 2000).

4.11 APPLICATION OF MDA IN CONSTRUCTION RELATED RESEARCH

Regression analysis requires continuous dependent variables (Press *et al.*, 1978). However, many attitudes, behaviours, decisions and events are measured in discrete or non-continuous ways (George *et al.*, 1994) for example, classification of firms as failed or non-failed (Akintoye *et al.*, 1995). A number of statistical methods are available to analyse such situations including discriminate, linear probability, logit and probit analyses (Lacity *et al.*, 1994; and Kleinbaum *et al.*, 1994).

MDA was used in this research in order to classify the aptitude of CEPMs. A secondary aim was to find out the most important factors and variables that impact on the CEPM.

As a direct result of modern computer facilities, MDA has become very popular among researchers. Another notable feature of modern software is that it is possible to give a graphical description of the data, which is more easily assimilated and interpreted than a numerical one. The graphical display can assist in summarising a large mass of numerical data, simplifying the aspect of the data by appealing to our natural ability to absorb visual images and providing a global view of the information, thereby stimulating possible explanations.

To date the technique has generally not been applied in construction related research works, there being few references to previous research. However, of notice, Mason and Abidali *et al* 1998 applied the technique to predict company failure in the construction industry by taking financial ratios as the predictors.

Salomonsson and Flood *et al* 2001 also used the technique to classify building firms in Australia based upon the job area, job complexity, completion time and cost as the predictors.

Skitmore and Marsden *et al* 1997 used the method to investigate the decision making for different procurement methods based upon the following predictors: speed, certainty, flexibility, quality level, complexity, risk avoidance are responsibility and price competition.

4.12 ASSUMPTIONS OF MULTIVARIATE DISCRIMINATE ANALYSIS

As with all Multivariate Statistical Analysis techniques, random sampling, adequate sample size, reliable measures and correct model specification are generally assumed to be present. With MDA specifically, linearity (in the form of bi-variate scatter plot), homogeneity of variance/covariance matrices, univariate/multivariate normality and a low collinearity among IVs are assumed.

The category variable can have two or more distinct levels. Category membership must be mutually exclusive (each case must be classified into no more than one category) and collectively exhaustive (very case must be a member of a category). The following points are general assumptions for discriminate analysis:

- ✓ The predictor variables are multivariate normal, ipso facto univariate normal;
- ✓ The variance-covariance matrices of the predictor variables across the various groups are the same in the population, i.e. homogeneous;
- ✓ The groups defined by D*v* exist a priori;
- ✓ The predictor variables are noncollinear;
- ✓ The relationship is linear in its parameters; and
- ✓ Absence of leverage point outliers.

4.13 RELATIONSHIP TO MULTIVARIATE REGRESSION ANALYSIS

Two group linear discriminate analysis is closely related to multiple regression analysis (MRA). The binary grouping variables in the discriminate analysis can be treated as the dependent variable in mutable linear regression analysis and the predicator variables as the independent variables.

However, MRA is less powerful than discriminate analysis in the case of binary grouping dependent variables with only Yes or No alternatives. MRA is more suitable to cases where the dependent variable is a continuum. At the same time, it is regression statistic for making predictions when the dependent variable is a dichotomy (Tung, et al., 1985, Rummel *et al.*, 1984 and Kleinbaum., et al., 1994).

4.15 SUMMARY

Consequently, MDA as a whole is concerned with the relationship between a categorical variable and a set of inter-related variables. MDA is a powerful statistical analysis, where a set of multiple outcomes (dependent variables) and one or more independent variables (covariates) are used for a prediction or forecasting and classification future situations (Sharma., et al., 1996). Using MDA, a function can be derived which can maximize the group!. A cut off point is able to be established in the two groups, thus the group membership can be assigned when the score is known.

The advantages of this technique in performance appraisal are as follows:

- It is a multiple approach which can consider the entire profile of all the attributes that affect the dependent variable (in this research, the CEPM's aptitude.
- The interrelationship between attributes can be taken into consideration.
- The classification tool is a straight forward function which is easy to interpret and use.
- A quantitative approach is provided which can reduce the effect of subjective judgement in contractor evaluation.

MDA and its assumptions about the data were discussed in this chapter. Based on the technique that had been selected for this research, the questionnaires have been developed.

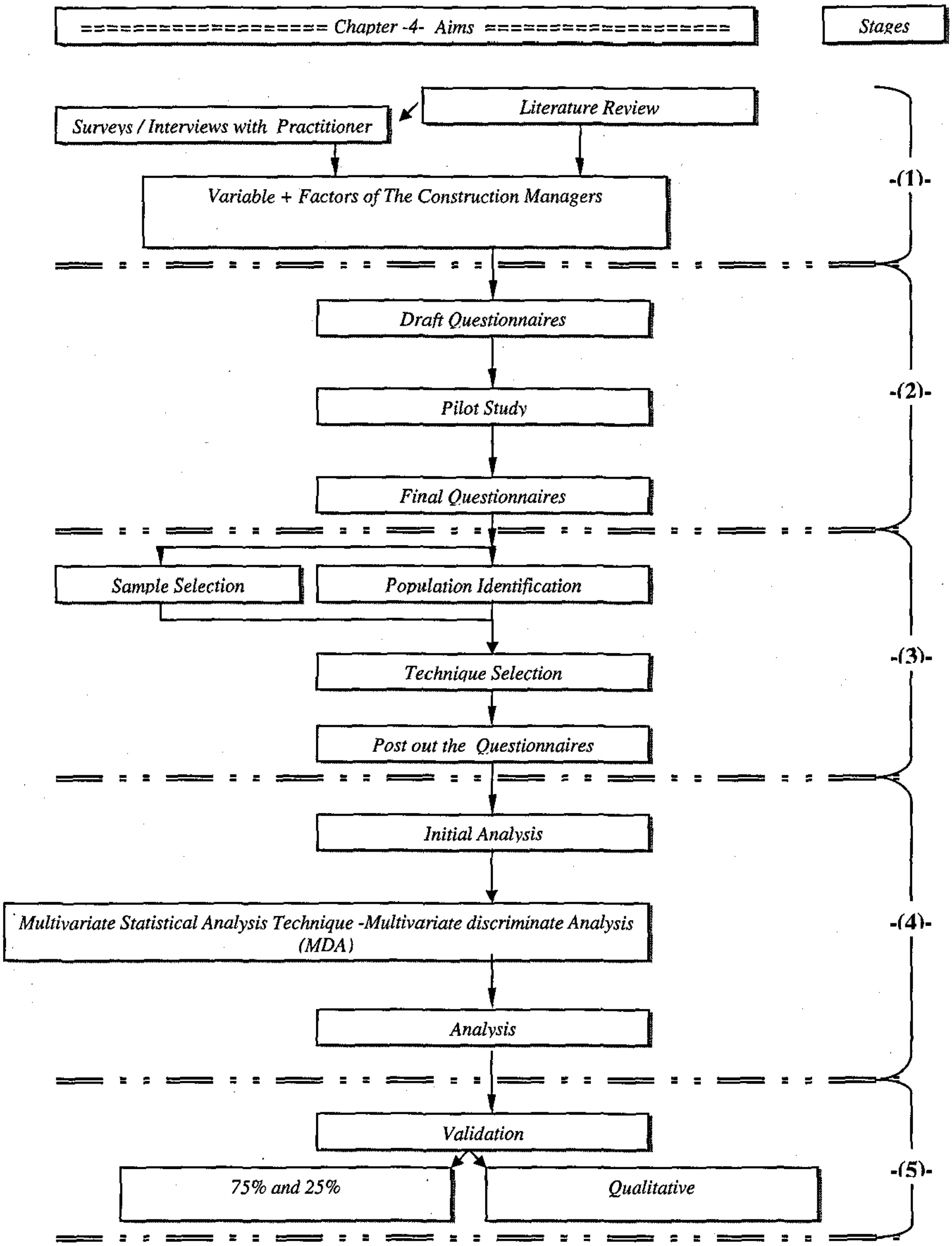
CHAPTER 5
Survey Design and Implementation

5.0 INTRODUCTION

In this chapter a methodology for classifying a CEPM's ability to successfully manage a construction project will be proposed. Although a range of statistical techniques will be used, the main classification technique, Multivariate Discriminate Analysis (MDA) will be used in the modelling process. To give structure and provide a logical solution, the work has been divided into five key stages purely to illustrate the logical process via which the work has been pursued. Refer to Figure 5.1.

These stages included: i) a literature review in order to find out the essential factors and variables that have been reported upon in past research; ii) the development of questionnaires to be used as the main data capture mechanism; iii) The commencement of the field research work which includes population identification, sample selection, etc; v) the analysis itself which included both summary statistical analysis and multivariate discriminate analysis (MDA); and the classification models developed using two approaches which included both a quantitative and qualitative procedures.

Figure 5.1 The Methodology Structure.



5.1 SAMPLE DESIGN & POPULATION IDENTIFICATION

A major challenge for any study is the need to elicit opinions or attitudes without introducing observer bias (Alreck *et al.*, 1995). Whenever a questionnaire is designed or interview conducted, there is a danger that error (or bias) may be introduced into the process by the fact that the designer or interviewer influences the inputs and hence, the outputs (Frazier *et al.*, 1945). Indeed, bias is further exacerbated when the expert tries to predict what practitioners actually experience and belief (Freeman *et al.*, 1983).

These potential problems are not new and are common in the social sciences arena (Kalton *et al.*, 1977). One practical method that attempts to avoid serious bias is Kelly's Repertory Grid (Yung *et al.*, 1998). Interestingly, Kelly was trained as an engineer before becoming a widely respected psychologist of the 1930's and the key elements of Kelly's theory are that:

- Perceptions influence expectations and expectations influence perceptions.
- The medium through which this happens is known as the construct system.
- Construct systems are unique to the individual and develop throughout life (Lewis *et al.*, 1995).

To accurately measure people's attitudes and beliefs, it is first necessary to ensure that the right questions are being asked (Oppenheim *et al.*, 1992 and Martin *et al.*, 1993). Kelly's Repertory Grid can be an invaluable resource as it can help to discover areas that a questionnaire should cover and the best ways of expressing data collection points (e.g. questions) on paper, and in a language that practitioners can recognise (Rudestam *et al.*, 1992). Within this research, reference to Kelly's Repertory Grid will be made in an attempt to improve upon questionnaire design and reduce bias.

It is incumbent on the researcher to clearly define the target population (Alreck *et al.*, 1995). There are no strict rules to follow and therefore logic and judgment must be used (Miles *et al.*, 1994). The population is defined in keeping with the objectives of the study. Sometimes, the entire population will be sufficiently small and the researcher can include the entire population in the study (Moser *et al.*, 1979). This type of research is called a census study because data is gathered on every member of the population (Teijlingen *et al.*, 2001). Normally however, the population is too large for the researcher to attempt to survey all of its members (Alreck *et al.*, 1995). An important issue is to therefore choose the sample that can be used to represent the population because the essentially sample reflects the characteristics of the population from which it is drawn (Altmann *et al.*, 1974).

Although questionnaires represent an economic data collection mechanism, it would have been physically and practically impossible to target the entire population of all construction and civil engineering professionals employed within the UK's for this survey (Beach *et al.*, 2000). Indeed, statistical concepts mean that the entire population should not be approached (Sekaran *et al*, 1997 and Neuman *et al*, 2000). It was therefore necessary to identify a representative sample of the population for inclusion in the research project. At the same time, sample size required for a survey partly depends on the statistical quality needed for survey findings (Forza *et al.*, 2002). This in turn, relates to how the results will be used (Alreck *et al.*, 1995). In this research the targeted population was CEPMs within the UKs civil engineering and construction industries.

For statistically acceptable results to be obtained from a survey questionnaire, Alreck and Settle (1995) suggest that 60 responses is the minimum number required to be evaluated, while the practical maximum number of responses is 1,000. in certain texts however, it has been acknowledged that 40 responses produce a statistically good grounding and have the ability to portray the population's characteristics correctly (Oltman *et al*, 1991). It was initially assumed that the response rate to the survey would be between 20-50%. This response rate identified that 500 CEPMs should be targeted with the questionnaire to obtain the acceptable response numbers, which is more than the minimum response numbers needed.

5.2 PILOT STUDY

Before any scientifically robust questionnaire was presented to the sample, a pilot study was completed in order to determine the correctness, clarity and completeness of this important data collection instrument (Mason *et al.*, 1995). This included: testing how long it takes to complete, checking that the questions are not ambiguous, checking that the instructions are clear and eliminating questions that do not yield usable data (Muoio *et al.*, 1995). Some researchers (Deville *et al.*, 1992, Gable *et al.*, 1994 and Forza *et al.*, 2002) contended that when developing a questionnaire survey from scratch, it is advisable to perform two pilot studies (Lindquist *et al.*, 1991). Naoum (1998), describes a pilot study as:

getting the bugs out the instrument (questionnaire) so that the subjects in the main study will experience no difficulties in completing it and so that a preliminary analysis can be completed to see whether the wording and format of questions will present any difficulties when the main data are analysis.

The key issue is whether the respondents understanding of the questions do or do not match what the researcher had in mind (Greenfield *et al.*, 1996).

It has also been said that pilot studies are likely to be under discussed, underused and underreported (Prescott *et al.*, 1989) and full reports of pilot studies are rare in the research literature (Lindquist *et al.*, 1991, Muoio *et al.*, 1995 and Teijlingen *et al.*, 2001). When reported, they often only justify the research methods or particular research tool used. Too often research papers only refer to one element of the pilot study, for example, to the pre-testing or pilot testing of a questionnaire (De *et al.*, 1993). Such research simply states that: the questionnaire was tested for validity and reliability (Kalton *et al.*, 1995).

When pilot studies are discussed in more detail, researchers regularly comment that they had learned from the pilot study (Lindquist *et al.*, 1991) and made the necessary changes, without offering the reader details about what exactly was learnt (Prescott *et al.*, 1989). Both successful and failed pilot studies are very useful to others embarking on projects using similar methods and instruments (Mason *et al.*, 1995). This is particularly important because pilot studies can be:

time-consuming, frustrating, and fraught with unanticipated problems, but it is better to deal with them before investing a great deal of time, money and effort in the full study (Mason et al., 1995).

It has also been argued that the current research climate demands accountability from researchers i.e. research results are put to the best possible use (Crosswaite *et al.*, 1994). Well-designed and well-conducted pilot studies can inform us about the best research process and occasionally about likely outcomes (Naoum *et al.*, 1998).

For this research work, six organisations were initially identified as having regular contact with large numbers of construction and civil engineering professionals. These organisations being: British Constructional Steelwork Association (*BCSA*); Chartered Institute of Building (*CIOB*); Chartered Institute of Building Services Engineers (*CIOBSE*); Construction Industry Council (*CIC*); the Civil Engineering Contractors Association (*CECA*); and Construction Industry Training Board (*CITB*). In combination, these organisation's members represented the majority of construction and civil engineering professionals within the United Kingdom. These organizations were contacted by telephone and provided with a brief description of the research being undertaken. Generally, the response to the telephone calls was positive and a number of organisations welcomed this research work (i.e. the organization wanted to endorse the research).

Twenty five (25) questionnaires were posted for the pilot study to construction and civil engineering organizations operating in the United Kingdom. The sample was randomly selected (Bosnjak *et al.*, 2001) from the same targeted population in order to get useful and actual feedback. Feedback from respondents suggested that the questionnaires had good coverage in terms of content but required additional (but very minor) editorial work.

5.3 DATA COLLECTION

There are numerous ways with which to acquire information (Bradburm *et al.*, 1982 and Dillman *et al.*, 1978). The most common research methods are: literature searches, talking with people, focus groups, personal interviews, telephone surveys, mail surveys and internet surveys (Coolican *et al.*, 1990 and Gerland *et al.*, 1991). Therefore, there are several methods that can be considered to collect data in survey research and each method has advantages and disadvantages over the others (Kalton *et al.*, 1977). The choice will depend upon the type and size of the audience being studied, the purpose of the study, the available, budget and staff available, etc (Kalton *et al.*, 1995).

5.3.1 Mailed Survey

A mailed survey uses a printed questionnaire that is mailed or delivered to respondents and permits them to respond at will and return the survey via mail. The advantages of this method include the fact that it requires minimum administration time and it is relatively inexpensive to undertake (Moser *et al.*, 1979). The disadvantage is that it often requires a follow-up (call or letter) to acquire a response and it can be difficult to obtain accurate mailing lists (Linsky *et al.*, 1992).

5.3.2 Telephone Survey

This method involves calling respondents via telephone, typically on a spontaneous (as perceived by the respondent) basis, although it can also be done via scheduled appointment in consideration of the respondent's own schedule (Frazier *et al.*, 1945). It is also possible to use an automated system via touch-tone telephone that is linked to a computer-based interview system (Dillman *et al.*, 1978). This method can elicit a quick response and can be inexpensive if dialling is local and staff/volunteers are available. Conversely, answering machines can delay the process and callers may not always be able to contact a suitable interviewee (Dillman *et al.*, 1978).

5.3.3 Personal Interview (face-to-face)

To conduct a personal interview, the interviewer must meet respondents either spontaneously (such as in a public place) or via scheduled appointment (Oppenheim *et al.*, 1992 and Barath *et al*,. 1976). This method has advantages and disadvantages as other methods of collecting research survey data (Vaus *et al.*, 1993). The advantages include the fact that a quick response can be obtained because interviews can be undertaken in one location. Face-to-Face contact also offers a personal element of trust. This technique can also interview groups of people (e.g. families) at one time and also can reach inaccessible audiences. However, disadvantages include the fact that interviews are time consuming if conducted at the subject's location. There is also some evidence that respondents may be more likely to give socially acceptable answers rather than the raw truth (Dillman *et al.*, 1978).

5.3.4 Web-based Survey

Web based surveys involve posting a questionnaire via a server which is connected to the world wide web (www), with respondents typically replying from individual computers remotely (although computers can also be set up at a central interview site) (Bosnjak *et al.*, 2001). Some academics argue that web-based surveys allow a quick response to be obtained 24/7 anywhere on the planet (Dillman *et al.*, 1978). In addition, postage costs are reduced or eliminated and when using access database(s) held on the server, data manipulation and analysis can be automated. Respondents must have access to the web though and even then reminders may still be needed, (Bradburn *et al.*, 1982). In many cases, respondents to computer-administered surveys do not always interpret ordinary words and phrases uniformly. For example, computer-administered surveys present questions to all users in the same format, leaving the user to interpret of those questions. This seeks to standardize the materials thus making sure all respondents are exposed to the same stimuli. This practice is however, problematic because different users can interpret the same questions quite differently (Clark *et al.*, 1991 and Schober *et al.*, 1999).

Having considered the data capture mechanisms available, this research used a mailed survey, due to its inherent flexibility. However, the work was augmented by the use of face-to-face interviews that were conducted during pilot study work. The aim here was to build a rapport with respondents in order to build trust and thus elicit an honest response. During the main questionnaire distribution phase telephone interviews were also conducted to ensure that an adequate minimum number of responses could be obtained.

5.4 FACTORS AND VARIABLES OF CEPM

The interaction between personal characteristics and individual performance is complex and difficult to chart (Bresnen *et al.*, 1984). Whether a person works hard or effectively is influenced by many factors, including age, skills, personality, experience and motivation (Riggs *et al.*, 1988., Committee on Construction Management., 1987, Bresnen *et al.*, 1986, Rounds *et al.*, 1984, Ahmed *et al.*, 1998 and Dulaimi *et al.*, 2000). Hatchett *et al.*, (1980) also suggested that personal factors such as educational background influence the way in which project, management skills are acquired.

Seven major factors were derived from the literature review and were confirmed by participating collaborators during the pilot survey as having an influence upon a CEPM's capability (aptitude). Having determined the target population and data capture mechanism, the next logical steps sought to determine exact questions that would be posed to respondents in order to elicit independent variable data (Huberty *et al.*, 1992). These seven factors were i) *Personal*, ii) *Motivation*, iii) *Training and Education*, iv) *Management*, v) *Work Situational*, vi) *Project Quality and Controlling* and vii) *Planning* as shown in Table 5.1. While each of these factors are important, they represented a subjective term that may be open to individual interpretation and judgement by sample respondents. To focus the detail of research, each factor was subsequently split into numerous potential variables, for example, the personal factor would include the variables age, marital status, intelligence, dependability, personality, reliability, ...etc. Factors and variables (within factors) were then used to develop the main professional opinion questionnaire, which consisted of a series of questions and statements. Each questionnaire respondent was asked to read questions and statements carefully before rating and ranking the importance of each factor and variable listed.

Leading on from the literature review, a pilot study conducted (which was included quantitative and qualitative approaches for developing and creating the research questionnaires) identified seven generic factors as being the most important factors that can be impact upon the CEPM aptitude. Within each factors, several variables were also identified as being potentially important, for example variables age, gender, marital status etc. are belong personal variable and so for the other factors.

Table 5.1 Civil Engineering Project Manager Factors.

No	Factors	Code
1	**Personal Factors.**	**Pv**
2	**Motivation Factors**	**Bv**
3	**Education and Training Factors**	**ETv**
4	**Management Factors**	**Mv**
5	**Work Situational Factors**	**WSv**
6	**Project Quality Control Factors**	**QCv**
7	**Planning Factors**	**PLv**

5.5 PERSONAL VARIABLES (PV)

Ten questions/statements were presented to respondents in a tabular format and each of these were assigned a code number (e.g. *Pv1, Pv2, Pv3,* etc.) to provide ease of cross-referencing during data response collation. Respondents were asked to encircle the number on a Likert scale to indicate the level of importance (e.g. 1, 2, 3, 4, 5). Each question/statement was presented in a tabulated format.

Table 5-2 Personal Variable (Pv).

No	Variables	Code
1	**Age.**	**Pv1**
2	**Gender.**	**Pv2**
3	**Marital Statues.**	**Pv3**
4	**Personal Disposition.**	**Pv4**
5	**Reliability.**	**Pv5**
6	**Intelligence.**	**Pv6**
7	**Dependability.**	**Pv7**
8	**Personality Agreeableness.**	**Pv8**
9	**Flexibility.**	**Pv9**
10	**Cooperative.**	**Pv10**

For this research work, it was decided that a Likert scaling method should be adopted. There are a number of reasons that supported this decision but two are provided. First, it is one of the most common scale for obtaining attitude from respondents giving them the opportunity to position their attitudes towards a statement on a scale (Fellows *et al.*, 1997). Second, this scale is probably the most relevant if one wishes to study attitude patterns or explore relationships of attitude (Oppenheim *et al.*, 1992). The Likert technique present a set of attitude statements (Cox *et al.*, 1890). Subjects are asked to express agreement or disagreement of a five-points scale. Each degree of agreement is a given numerical value from one to five. Thus a total numerical value can be calculated from all responses.

The Likert scale used for this particular instrument rates the responses from *strongly agree* (5) *agree* (4) *uncertain* (3) *disagree* (2) *strongly disagree* (1).

Table 5.3 The Likert-Scale used in this Research.

Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
5	4	3	2	1

5.6 MOTIVATIONAL VARIABLES (BV)

Motivation has been defined in a variety of ways (Cheng *et al.*, 2001). However, Shermerhorn *et al.*, (1990) provides a good definition as the forces within an individual that account for the level, direction and persistence of effort expended at work.

McFillen and Maloney (1998) concluded that despite decades of experience acquired by construction practitioners, the industry has done little to improve the motivation of its workers. The authors (ibid) argued that motivation is not the responsibility of managers but rather those who leader them. Hence, management should be aware of their role in motivating employees if the organization they work for are to have a realistic probability of surviving (Grote *et al.*, 2002). Of all the functions a manager performs, motivating employees is arguably the most complex (Bittel *et al.*, 1990 and Frunzi *et al.*, 1997).

At one time, employees were considered just another input into the production of goods and services (Stipek *et al.*, 2002). What perhaps changed this erroneous perception was research, referred to as the Hawthorne Studies, conducted by Elton Mayo from 1924 to 1932 (Dickson *et al.*, 1973). This study found employees are not motivated solely by money and that employee behaviour is directly linked to their attitudes (Dickson *et al.*, 1973). The Hawthorne Studies began the human relations approach to management, whereby the needs and motivation of employees became the primary focus of managers (Bedeian *et al.*, 1993).

Motivated employees are needed in our rapidly changing workplaces (Smith *et al.*, 1994). Motivated employees help organizations to become more productive (Terborg *et al.*, 1978). To be effective employees, managers need to understand what triggers motivates employees perform their roles and duties more effectively and efficiently. Motivation for CEPMs can be modelled on several factors such as specific needs of the CEPM, social influences, personal attitude, and so forth (Landy *et al.*, 1989). However, motivators can also be categorised into two broad dichotomous groups of financial or non financial (Cheng *et al.*, 2001). A mere raise in responsibilities can give a rise to a discontent non performing employee whose productivity will only decline (Terborg *et al.*, 1978). To keep a person motivated, an equal share of responsibilities and rewards should be simultaneously extended by an effective leader for the achievement of set goals (Stipek *et al.*, 2002).

Numerous variables were observed in the literature but only six were confirmed by participating collaborators during the pilot survey as having an influence upon the CEPM's capability. These variables are listed in Table 5.4. However, the literature clearly confirms that other variables that are non-financial are equally important. These include management responsibility, training and education opportunity etc. and these variables are included in other sections of the questionnaire. For sake of simplicity, it was felt that any duplication of question in this section would confuse the respondent; indeed pilot work conformed this hypothesis.

Table 5.4 Motivation Variables (Bv).

No	Variables	Code
1	**Pay/salary/wages.**	**Bv1**
2	**Fringe benefits.**	**Bv2**
3	**Additional payment for output of quality work.**	**Bv3**
4	**Team-based-bonus on timely project completion.**	**Bv4**
5	**Additional payment for finishing the project on time or early.**	**Bv5**
6	**Job promotion recognition.**	**Bv6**

5.7 EDUCATION AND TRAINING VARIABLES (ETV)

It was argued by pilot study respondents that one of the most important factor was education and training. In the absence of an in-depth knowledge of relevant construction science, a project was almost certainly doomed to failure.

Five potential variables were identified under the heading of training and education factors. Under this section, each question was presented in a tabulated format and was coded as *ETv1, ETv2, ETv3* and so on. Table 5.5 presents the question/statements posed to respondents.

Table 5.5 Education and Training Variables (ETv).

No	Variables	Code
1	**Qualification.**	**ETv1**
2	**Background.**	**ETv2**
3	**Experience (practical building knowledge).**	**ETv3**
4	**Training in the project management.**	**ETv4**
5	**Continual professional certificates.**	**ETv5**

5.8 MANAGEMENT VARIABLES (MV)

Project management is a people business and the foundation of project management effectiveness lies with the people involved, both individually and collectively (Ahmed *et al.*, 1998). The essence of effective project management lies in the fitness for duty and the ability of the people on the team to become of one mind and to bond with one goal. It is not surprising that people, their capabilities and ways they are organised, are central to success of construction projects. Based upon the literature review thirteen potential variables were identified the under management factor and were coded *Mv1, Mv2, Mv3* and so on. Table 5.6 provides a list of variables covered together with a variable code.

Table 5.6 Management Variables (Mv).

No	Variables	Code
1	**Responsibility**	**Mv1**
2	**Authority.**	**Mv2**
3	**Accountability.**	**Mv3**
4	**Leadership.**	**Mv4**
5	**Control.**	**Mv5**
6	**Time management.**	**Mv6**
7	**Problems solving capabilities.**	**Mv7**
8	**Dependability.**	**Mv8**
9	**An ability to create clear management policies.**	**Mv9**
10	**The ability to supervise personnel on site.**	**Mv10**
11	**Involvement in the production and/or management legal contracts.**	**Mv11**
12	**Influence in decision-making.**	**Mv12**
13	**Involvement in the preparation of the project budget.**	**Mv13**

5.9 WORK SITUATIONAL VARIABLES (WSV)

The time it takes to complete construction projects from inception to completion is of great importance in the construction industry. Clients or consumers are no longer content merely with minimal cost and adequate functional performance for their projects; increasing interest rates, inflation and other commercial pressures mean that in many instances a project must be completed in the shortest possible time for it to be cost effective. Work situational variables has been widely accepted by practitioners to be of significant importance since the work environment will affect the construction and/or civil engineering activities in a variety of ways.

Seven variables were identified under work situational factors as having a potential influence upon the ability of the CEPM to deliver a successful project and were coded *WSv1, WSv2, WSv3*, and so on. Table 5.7 lists these variables and also provides an appropriate variable code.

Table 5.7 Work Situational Variables (WSv).

No	Variables	Code
1	**Work in extreme weather.**	**WSv1**
2	**Site conditions.**	**WSv2**
3	**Project complexity.**	**WSv3**
4	**Working under pressure of time.**	**WSv4**
5	**An ability to ensure the health, safety etc.**	**WSv5**
6	**Site organisational abilities.**	**WSv6**
7	**Obtaining good co-worker support.**	**WSv7**

5.10 PROJECT QUALITY AND CONTROL VARIABLES (QCV)

Quality control represents an increasingly important concern for modern CEPMs (Barber *et al.*, 1992). Defects or failures observed once a construction project has been completed can result in very large costs (Webster *et al.*, 1999). Even with minor defects, re-construction (alternatively knows as rework) may be required and facility operations impaired (Lee *et al.*, 1992). With the result that increased costs and delays are the result (Brache *et al.*, 1988, Smith *et al.*, 2002, Abdul *et al.*, 2002 and Bossink *et al.*, 2002). In the worst case, failures may cause personal injuries or fatalities (Settle-Murphy *et al.*, 1997). As with cost control, the most important decisions regarding the quality of a completed facility are made during the design and planning stages rather than during construction (Bresnen *et al.*, 1984, Rounds *et al.*, 1985, and Xiao H., and Proverbs *et al.*, 2003). It is during these preliminary stages that component configurations, material specifications and functional performance are decided (Battikha *et al.*, 2003). Quality control during construction consists largely of ensuring conformance to these original design and planning decisions (Price *et al.*, 2003).

Eight variables were identified under project quality and controlling as having a potential influence on achieving project success. Under this section, questions and/statements were coded *QCv1, QCv2, QCv3*, and so on. Table 5.8 lists the eight quality and control variables and provides an appropriate variable code.

Table 5.8 Quality and Control Variables (QCv).

No	Variables	Code
1	**Ensuring project quality in order to achieve customer satisfaction.**	**QCv1**
2	**Establish a quality-centred environment among project stakeholders.**	**QCv2**
3	**Creating a quality management plan to deliver promised value.**	**QCv3**
4	**Translate expectations into specific deliverables to meet customer requirements.**	**QCv4**
5	**Employ quality assurance processes, tools and metrics.**	**QCv5**
6	**Maintain project control correct deviations and avoid defect recurrence.**	**QCv6**
7	**Include all contributors in the monitoring process.**	**QCv7**
8	**Planning general alternative for each contingency.**	**QCv8**

5.11 PLANNING VARIABLES (PLV)

Writing the project plan provides a structured framework for thinking about how the project will be conducted, considering the project risks (Dunlop *et al.*, 2004). Construction project planning is an essential and challenging activity in the management of construction projects (Friend *et al.*, 1987). It involves the choice of appropriate technology, the definition of work tasks, the estimation of the required resources and durations of individual tasks and the identification of any interactions among the different work tasks (Zhang *et al.*, 2005). A comprehensive plan may require the involvement of functional experts and decision makers (Zozaya *et al.*, 1985). A good construction plan is the basis for developing the budget and the schedule for work (Au *et al.*, 1985). Developing the construction plan is a critical task in the management of construction even if the plan is not written or otherwise formally recorded (Jackson *et al.*, 1986).

Six variables were identified under planning the project as having a potential influence on achieving success project. These variables have been widely accepted by practitioners to be important. Under this section, the question/statement were coded *PLv1, PLv2, PLv3*, and so on. Table 5.9 lists the six planning variables and provides an appropriate variable code.

Table 5.9 Planning Variables (PLv).

No	Variables	Code
1	**Schedule the whole project at the beginning.**	**PL*v*1**
2	**Recognize interdependence of the parts.**	**PL*v*2**
3	**Identify the critical items early.**	**PL*v*3**
4	**Seeking the best cost estimates for works undertaken.**	**PL*v*4**
5	**Quality materials selection and storage.**	**PL*v*5**
6	**Selection of appropriate plant and equipment**	**PL*v*6**

5.12 TECHNIQUE SELECTED FOR THIS RESEARCH

MDA may be defined as the analysis of data with three or more variables, that is, where there are a minimum of three measures for each individual under consideration (Anderson *et al.*, 1984 and Johnson *et al.*, 1998). There are a variety of multivariate techniques available to the empirical researcher (Klecka *et al.*, 1980). These include Factor Analysis (FA), Multivariate Discriminate Analysis (MDA), Multivariate Analysis of Variance (MANOVA), Canonical Correlation Analysis (CCA), Covariance Structure Analysis (CSA) and Cluster Analysis (CA) (Kim *et al.*, 1978, Diday *et al.*, 1983, Hartigan *et al.*, 1975, Johnson *et al.*, 1982 and Everitt *et al.*, 1980). For this research Multivariate Discriminate Analysis (MDA) was used as an appropriate technique based on the research objectives. Essentially the various techniques may be classified as either hierarchical, (linear composite) where one variable affects another as in Factor analysis; or clustering where group membership is predicted based on similar measures, as in Cluster Analysis (CA) (Kaufman *et al.*, 1990). Lance and Williams (1967) perceive greater detail and suggest that computer classification techniques fall into four categories, namely: (i) simplification, (ii) overlapping classification, (iii) divisive methods, and (iv) agglomerative methods. Both divisive (where a single large group is successively broken down into smaller groups of like elements) and agglomerative (where individuals are progressively grouped into fewer and large cluster) are methods which may be either hierarchical or clustering (Huberty *et al.*, 1992). While hierarchical (or multilevel) methods have attained a highly level of sophistication through techniques mentioned above, cluster analysis remains an exploratory classification procedure, which is conceptually different (Berry *et al.*, 1997).

Hierarchical schemes, focus on predicting how one quantity affects another, while recognising that they are different variables quantified by different measures (Maurice *et al.*, 1983). These strategies are used to predict a criterion variable (as in Multiple Regression); group membership (as in Discriminate Analysis); group comparison (as in Analysis of Variance); and structure (for example Factor Analysis). By contrast, single-level Cluster Analysis attempts to relate response variables (Maurice *et al.*, 1983).

Cluster analysis is the grouping of similar objects into a subset of objects (Everitt *et al.*, 1980). The naming of minor planes and the classification of astronomical sightings are typical clustering problems (Congalton *et al.*, 1991). In cluster analysis scores are grouped together with no predetermined group membership and an attempt is made to optimize a group, rather than a route (Eisen *et al.*, 1998). This is the opposite of MDA where the variables have known group membership and only need to determine which of the variables are good description of the group (Sikkonen *et al.*, 2002). Cluster analysis may also be exploratory in the sense that are processing a number of variables in the hope of establishing some pattern from which a theory may develop (Lance *et al.*, 1967; Aldenderfer *et al.*, 1984). So, typically cluster analysis is used as a check on the validity of findings made using other techniques (Kaufman *et al.*, 1990).

The term Multivariate Statistical Analysis (MSA) is appropriately used to include all statistics where there are more than two variables simultaneously analysed (Hair *et al.*, 1992). MSA is an important data analysis technique that has found applications in various areas i) for developing taxonomies or systems of classification, ii) for investigating useful ways to conceptualise or group items iii), for generating hypotheses and iv) for testing hypotheses.

Clustering techniques have been applied to a wide variety of research problems (Everitt *et al.*, 1980). Hartigan in 1975, provides an excellent summary of the many published studies reporting the results of cluster analysis. For example, in the field of medicine, clustering diseases, cures for diseases, or symptoms of diseases can lead to very useful taxonomies (Romesburg *et al.*, 1984). In the field of psychiatry, the correct diagnosis of clusters of symptoms such as paranoia, schizophrenia, etc. is essential for successful therapy (Kaufman *et al.*, 1990). In archaeology, researchers have attempted to establish taxonomies of stone tools, funeral objects, etc. by applying cluster analytic techniques (Aldenderfer *et al.*, 1984). In the field of construction and civil engineering, researchers found that good tools for applying this technique in order to achieve better performance and quality project management (Porter *et al.*, 1988; Solvell *et al.*, 2003; Ketels *et al.*, 2004). In general, whenever one needs to classify a mountain of information into manageable meaningful piles, cluster analysis is of great utility (Maurice *et al.*, 1983).

Clustering methods are discussed in various text books (Hartigan *et al.*, 1975, Jain *et al.*, 1988). These methods have various techniques and can be performed in many ways. In case of more than two variables, use of mathematical models and computer programmes becomes necessary for the analysis of data (Sharma *et al.*, 2002). There are a few methods that start by considering all records to be part of one big cluster and then splits them into two or more smaller cluster (Romesburg *et al.*, 1984). There are also methods that start with each recode taken as a cluster, and iteratively combine to form clusters (Sikkonen *et al.*, 2002). The former methods are called Divisive methods and the latter Agglomerative methods (Romesburg *et al.*, 1984, Kaufman *et al.*, 1990 (Romesburg *et al.*, 1984).

Within cluster analysis technique, the most-often used clustering techniques are hierarchical clustering and non-hierarchical (disjoint) clustering (Maurice *et al.*, 1983). The hierarchical clustering is very much a tree-like procedure (Diday *et al.*, 1983). It proceeds by either a series of successive mergers (often called agglomerative hierarchical methods) or a series of successive divisions (called divisive hierarchical methods). Agglomerative hierarchical methods start with the individual sample points as n cluster of one observation each (Hartigan *et al.*, 1975). The number of clusters is then reduced to n-1 by merging two of the points into a single group based on some measure of similarity between them, applying some optimality criterion. The process is continued until the desired number of groups remains (Lance *et al.*, 1967; Aldenderfer *et al.*, 1984; Diday *et al.*, 1983). On the other hand, divisive hierarchical methods work in the opposite direction by starting with one group of *n* observations and dividing this group into smaller groups based on some measure of distance between them until some optimality criterion is satisfied.

The non- hierarchical clustering techniques are designed to group observations into *k* disjoint cluster so that the total within group distance is minimized (Diday *et al.*, 1983). The number of cluster, k, may either be specified in advance or determined as part of the clustering procedure. The *k*-means method is a popular non-hierarchical procedure. It first assigns the observations into k initial clusters. In each iteration, the distance between an observation's location (based on the observation's values for the variables that define the clusters) and cluster centres are calculated. The observation remains in the same cluster or is assigned to different clusters according to the distances. The cluster centres (means) are then updated. The iterations continue until no more reassignments take place. Non-hierarchical/disjoint clustering techniques can handle a much larger data set than hierarchical techniques (Mojena *et al.*, 1977).

Generally, cluster analysis encompasses a group of data exploration techniques that are used to search for a structure of natural groupings of *multidimensional* objects or observations according to their degree of similarity or distance. Clustering is distinct from classification methods (Ketels *et al.*, 2004). Classification pertains to a known number of groups (classes) and the operational objective is to assign new observations to one of these groups. At the same time, cluster analysis is a more primitive technique in that no assumptions are usually made concerning the number of groups or the group structure. Thus, the objective of cluster analysis is to discover natural groupings of the observations such as that observations in a given cluster tend to be similar in some sense to other observations in the same cluster and dissimilar to observations in other clusters (Sikkonen *et al.*, 2002). Data is thus arranged in two matrices, called data matrix and dissimilarity matrix. While data matrix is a representation of n objects (such as construction managers) with m attributes (such as gender, age, social status, qualification etc.), dissimilarity matrix is a collection of distances between the pair of objects.

5.13 ASSUMPTIONS ABOUT THE DATA

An MDA mathematical model is based on certain crucial assumptions and if these assumptions are violated, the statistical results will not be a precise reflection of reality (Sikkonen *et al.*, 2002). For the linear discriminate function to be optimal, that is, to provide a classification rule that minimizes the probability of misclassification, the following assumptions about the data must be met:

i. In each group, the variables must be form multiple normal distributions.
ii. The population covariance matrices for all groups must all be equal.

In testing the first assumption, a simple tactic is to first examine the distributions of each of the variables individually. If the variables are jointly distributed as a multiple normal, it follows that each is individually distributed normally. Therefore, if any of the variables have markedly non-normal distributions, there is reason to suspect that the multiple normally assumption is violated. For the second assumption, Box's M test is used to test the quality of the group covariance matrices. A small probability might lead to reject the null hypothesis that the covariance matrices are equal. The test is also sensitive to departure from multiple normality. That is, matrices tend to be unequal if the normality assumption is violated. These two assumptions are not always satisfied in practice. However, the technique has been found to be very robust implying that the assumptions need not be strongly adhered to.

5.14 SUMMARY

Research often use sample survey methodology to obtain information about a large aggregate or population by selecting and measuring a sample from that population. Due to the variability of characteristics among items in population, researchers apply scientific sample designs in the sample selection process to reduce the risk of a distorted view of population, and that make inferences about the population based on the information from sample survey data.

A comprehensive literature review established a robust sample design and population. The main generic factors and variables that have been found in the literature review that impact upon the CEPM's aptitude were also included. The main methods of collecting and formatting the data were studied and reported upon, these include mail, telephone, personal interview and web-based survey. It was decided that although a mail survey would be used as the main capture mechanism, telephone and personal interviews would also be used to increase the response rate. A pilot study conducted then served to refine and amend the main survey questionnaire that was subsequently post to 500 CEPMs within the UK construction industry.

CHAPTER _6_
The Classification Research Methodology

6.0 INTRODUCTION

Research outcomes are often presented in terms of statistics to prove the strength of the relationship between two or more variables and either predict trends or classify data into dichotomous groups (Sekaran *et al.,* 1992). The fundamental aim of this chapter was to prescribe a systematic methodology with which to further this research work. In particular, this chapter elucidates upon the procedures used for data manipulation. This includes calculating the Importance Rating (*IR*), and Response Rating (*RR*) and transposing these scales into Weighting Indices (*WI*) of main generic factors and variables that could be utilised to quantify a CEPM's ability. Independent variable scales (for example, age, experience, education and so forth) and the procedure used to drive the quantitative dependent variable classification procedure are also detailed. Finally, an introduction to the classification techniques that will be utilised during the modelling phase are elaborated upon.

6.1 THE CLASSIFIACTION RESEARCH METHODOLOGY

An overview of the methodology is presented diagrammatically in Figure 6.1. The research survey gathered opinions and perceptions of the CEPM regarding potential variables (attributes) that could be used to classify the aptitude required by the successful CEPM. From the CEPM opinion attitudinal research data, mathematical modelling of independent variables was employed to classify the aptitude of CEPM into one of three categories, namely, good, average and poor (the dependent variable classifications). The classification process itself consisted of four broad stages, namely:

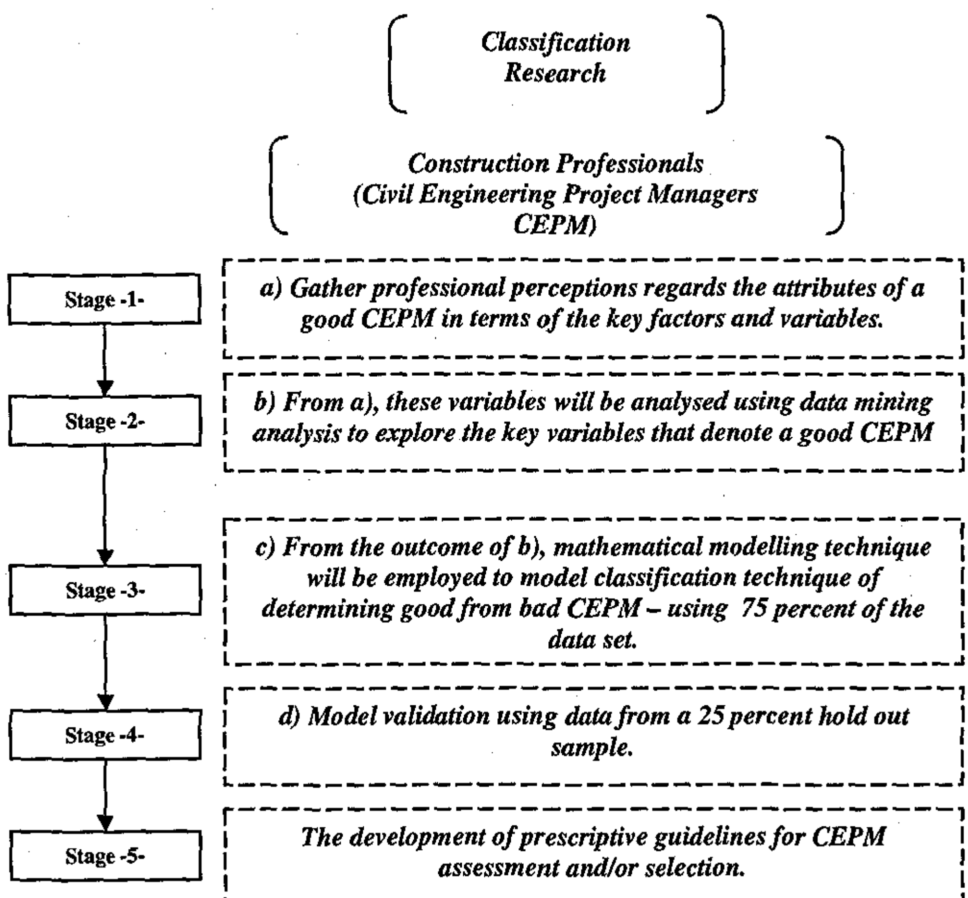
i. determination an importance rating (*IR*) and rank rating (*RR*) of all factors and variables hypothesised as potential classification determines;
ii. transposition of the *IR* and *RR* ratings into a weighting index so that the relative importance of one variable or factor could be directly compared to others in term of percentage;

iii. quantification of scales of measurement for both independent and dependent variables; and

iv. utilisation of the culmination of research outcomes emanating from (i) to (iii) to propose a suitable method with which to group civil engineering project managers s (CEPM's) using appropriate classification techniques.

Thereafter, results from the combined analysis were utilised (once evaluated and validated) to derive prescriptive guidelines for determining the attributes of the optimum CEPM.

Figure 6.1 Details of Classification Research Methodology.



6.2 DATA MINING

Discursive statistical observations were conducted on the survey data and various summary statistical procedures were utilised such as measure of central tendency (e.g. mean, media, standard division, interquartile range), test of normality (e.g.

skewness measure or Kolmogorov-Simirnov test statistic) and correlation. Whilst such statistics are simplistic, they enabled a more in depth appreciation of the data to be acquired and also provided an intuitive feel for professional opinion. This initial data mining, also provided an invaluable insight into potential data manipulation during the modelling process. Data manipulation used included possible data transformations (e.g. using Log_{10}, square root and/or Log_e to achieve normality) and generating quantitative variables from qualitative data using Boolean binary codes. The initial modelling of data then commenced, principally via the transposition of the raw data into importance response rating (*IR*) and rank rating (*RR*) as a procures to production of a weighting index (*WI*). Because *WI* would form the basis of the CEPM profile, further discussion is required to elucidate upon the *IR, RR and WI.*

6.3 THE IMPORTANCE (IR) AND RANK (RR) RATING

The Importance Response rating (*IR*) sought to capture professionals opinions regarding their perceived importance for each generic factor and variables detailed in the survey using a five-point Likert scale (i.e. 5 = very important; 4 = sometimes important; 3 = neither important or not important; 2 = often not-important; and 1 = never important vibe Chapter 5). This scale was then transformed into equivalent values for the *IR* ratio scale (refer to Table 6.1). This method was originally utilised in construction research studies by Olomolaiye (1987) and subsequently by Kometa, et al (1994) (cf. Holt, 1995) albeit Cabahug (2003) established a general methodological approach that will be adopted for this research work. These previous researchers stressed that the aggregate *IR* for each variable should be converted to a level of relative importance via formula 6.1:

$$IR = \frac{\sum \text{variable point score}}{5N} \qquad \text{Eq. 6.1}$$

Where N is total number of respondents (sample size) and 5 is the scale's strengths.

Hence, where respondents rate a variable as being very important (i.e. a Likert scale value of 5) would achieve an index of 1.0 with a decline in perceived importance being mirrored be a decline in *IR*, down to a minimum of 0.2 (i.e. a Likert scale value of 1). This procedure performs equally well on different scales (i.e. 1 to 10). The resultant *IR* represents a 50 percent contribution to the final *WI*, the remaining 50 percent is derived from the *RR*.

Table 6.1 Example of *IR* Calculation.

Respondent	*IR* points score
1	
2	*IR* points score range from
3	1 to 5 (i.e. 0.20 to 1.0)
.	.
.	.
.	.
N	∑ variable points score values

Within the *IR* section of the questionnaire, respondents were then invited to rank the factors and variables according to their importance. Ranking factors and variables enabled the exact importance of each variable to be accurately pin-pointed, particularly when a number of factors and variables, within a section, were denoted as being of equal importance in terms of *IR*.

The calculation procedure used to derive *RR* ratio scale is presented in Tables 6.2 to 6.4. In Table 6.2, a Likert ranking response scale of 1 to 7 was used while Table 6.3 uses an equivalent 1 to 10 ranking response scale. Akin to the procedure for calculating *IR* values, the *RR* values are transformed, summed (vibe Table 6.4) and divided by the chosen measure of central tendency. This simple calculation is expressed as:

$$Mean = \frac{\sum \text{Total Rank Values}}{N} \qquad \text{Eq. 6.2}$$

Where *N* is total of respondents.

Table 6.2 *RR* Equivalent Scale for 7-scale Ranking.

Ranking Response rating	Equivalent *RR* points scale
1	0.14
2	0.28
3	0.42
4	0.57
5	0.71
6	0.85
7	1.0

Table 6.3 *RR* Equivalent Scale for 10-scale Ranking.

Ranking Response rating	Equivalent RR points scale
1	0.1
2	0.2
3	0.3
4	0.4
5	0.5
6	0.6
7	0.7
8	0.8
9	0.9
10	1.0

Table 6.4 Example ***RR*** Calculation.

Respondent	Rank Value
1	1-5 (i.e. 0.2 to 1.0), 1-10 (i.e. 0.1 to 1.0)
2	or 1-7(i.e. 0.14 to 1.0)
3	.
.	.
.	.
N	
	∑ Total rank values

6.4 THE USE OF A WEIGHTING INDEX (WI): CONCEPTS AND APPLICATION

The weighting index provides a mean of expressing the importance of a given factor or variable (Hannagan, *et al.*, 1986). Formula 6.3: provides a formula for calculating the *WI*.

$$WI = 0.5\,IR + 0.5\,RR \qquad \text{Eq. 6.3}$$

Where: *WI* is the weighting Index; *IR* is the importance rating; and *RR* is the rank rating (cf. Holt, 1995). *WI* provides a balanced input of *IR* and *RR*. Derived values of WI of each of the seven factors were then translated in terms of percentage importance, relative to (formula 6.4) a civil engineering project manager's Aptitude (CEPMA). Mathematically this is expressed as:

$$\textit{Importance of factor WI} = \frac{\textit{Factor WI}}{\sum \textit{Factors WI}} * 100\,\% \qquad \text{Eq. 6.4}$$

At a micro level therefore, when all individual *WI* values have been derived, the equation for the CEPMA can be written as:

$$CEPMA = f\,(aPv + bBv + cETv + dMv + eWSv + fQCv + gPLv) = 100\,\% \qquad \text{Eq. 6.5}$$

Where: CEPMA is the Civil Engineering Project Managers's Aptitude rate in percentage terms and is a function of: a) the percentage weight of the *Personal Factor* (P*v*); b) the percentage weight of the *Motivation Factor* (B*v*); c) the percentage weight of the *Education & Training Factor* (ET*v*); d) the percentage of the *Management Factor* (M*v*); e) the percentage weight of the *Work Situational Factor* (WS*v*); f) the percentage weight of the *Project Quality Control Factor* (QC*v*); and g) the percentage weight of the *Planning Factor* (PL*v*).

At a micro level, each variable within a generic factor also has a corresponding Weighting Index (*WI*) derived from *IR* and *RR* scales. Individual variable weighting indices were first calculated and then translated into a percentage value that would represent a contribution to its respective generic factor (formula 6.4). For instance, generic factor Pv (with ten variables identified) consists of ten percentage rations from associated variables. Pv can be presented mathematically as formula 6.6.

$$Pv = f(aPv1 + bPv2 + cPv3 + dPv4 + ePv5 + fPv6 + gPv7 + hPv8 + iPv9 + jPv10) = 100\% \qquad \text{Eq.6.6}$$

Where Pv is the Personal Factor in percentage; a) the percentage weight of *Age* (Pv_1); b) the percentage weight of Gender (Pv_2); c) the percentage weight of *Marital Status* (Pv_3); d) the percentage weight of *Personal Disposition* (Pv_4); e) the percentage weight of *Reliability* (Pv_5); f) the percentage weight of *Intelligence* (Pv_6); g) the percentage weight of *Dependability* (Pv_7); h) the percentage weight of *Personality Agreeableness* (Pv_8); i) the percentage weight of *Flexibility* (Pv_9); and j) the percentage weight of *Cooperative* (Pv_{10}).

Having completed numeric values for the *WI* for each generic factor and variables, the analysis focused on the development of a CEPM profile. That is, identify the relative importance of each individual factor and variables within factors. Consider the following illustrative example (refer Table 6.5).

Table 6.5 Illustrative Example.

Generic Factor	% Contribution	variable	% Contribution	Variable description
Pv	12.97	Pv1	08.52	Age
		Pv2	06.10	Gender
		Pv3	05.73	Marital status
		Pv4	10.93	Personal disposition
		Pv5	13.50	Reliability
		Pv6	12.79	Intelligence
		Pv7	11.67	Dependability
		Pv8	09.53	Personality agreeableness
		Pv9	10.50	Flexibility
		Pv10	10.74	Cooperative
Bv	14.42	Bv1	18.51	Basic salary
		Bv *n*...	n....	n ...
ETv	18.59	ETv1	19.31	Qualification
		ETv	n....	n ...
Mv	13.95	Mv1	10.43	The level of responsibility and autonomy given
		Mv	n....	n ...
WSv	08.25	WSv1	10.30	Working in extreme weather
		WSv	n....	n ...
QCv	14.57	QCv1	15.31	Ensuring project quality
		QCv	n....	n ...
PLv	17.40	PLv1	19.35	Scheduling key project activities at completion of the project design phase
		QCv	n....	n ...
Total	100.00			

Using the percentage importance of each generic factor, a CEPM's profile can be mapped. However, whilst all factors should be considered in the profiling process, further in-depth classification of each individual factor was required. The percentage importance of each variable was therefore considered in greater detail within each generic factor. For example, Pv contributes 12.97 per cent towards the aptitude of a CEPM and within this generic factor and variables Pv_1 to Pv_{10} account for 08.52, 06.10, 05.73, 10.93, 13.50, 12.79, 11.67, 09.53, 10.50, and 10.74 respectively. Using this knowledge, the next stage sought to define independent variable scales that could be mapped against the percentage importance values derived.

6.5 INDEPENDENT VARIABLE SCALE DETERMINATION

Whilst the professional opinion questionnaire aimed to determine the characteristics of the good CEPM (in order to facilitate the development of the aforementioned prescriptive guidelines) it can readily be assumed that the converse would indicate poor CEPM characteristics. Having defined and delineated the boundaries between good and poor CEPM characteristics, it could then be readily assumed that the average CEPM would lie between these two extremes. For example, by finding the most importance generic factor and the importance variable within this generic factor was prepared; this was the Education and Training factor (ET*v*) with a high ratio at 18.78 per cent. At the same time, within this generic factor (ET*v*) the Practical Building Knowledge variable (ET*v*3) was found to be the most importance variable due to its high score within the Education and Training factor's variables. Based on that, follow up phone calls were made to participating CEPM's who were asked what do you think about having practical building knowledge and was training or experience most important?. The vast majority stated that experience was the most important. Building upon this agreement and given that the variable practical building knowledge (ET*v*3) (which is shown in Table 6.6) accounts for 27.72 per cent of generic factor education and training ET*v*. Subsequent mapping of each factor and variable scale against the calculated percentage importance will enable industrial practitioners to benchmark their existing and new CEPMs aptitude against the optimum standard agreed by industry professionals. Table 6.6 show the contribution which was made by the ET*v* generic factor to the CEPM's aptitude.

Table 6.6 Contribution of ETv.

Generic Factor	% Contribution	variable	% Contribution	Variable description
ETv	18.59	ETv1	19.31	Qualification
		ETv2	17.38	Specific vocational background civil engineer, architecture engineer, etc.
		ETv3	27.72	Practical building knowledge and experience
		ETv4	18.10	Specific training in project management
		ETv5	16.78	Continual professional training
Total			100.00	

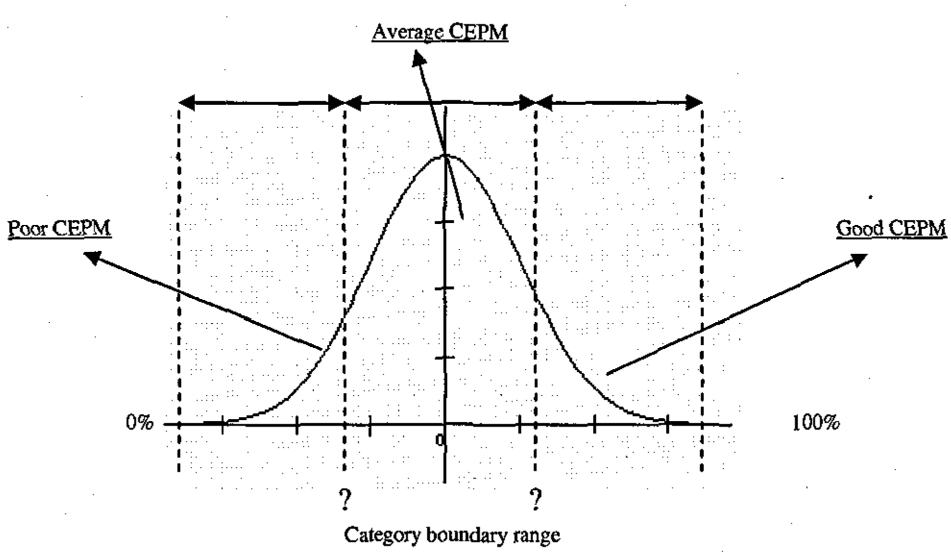
6.6 THE DEPENDENT VARIABLE CLASSIFICATION PROCEDURE

The main question with regards to the dependent variable was: what characteristics segregate good CEPMs from poor CEPMs within the dependent variable scale? The measurement scale for the dependent variable was represented in terms of percentage, ranging from 0 to 100. The CEPM with good characteristics will achieve a 100 per cent value. However, below this value, the boundaries that delineate and denote average and poor were less obvious.

Using the profile values derived from the weighting indices of variables, a random simulation will be generated to provide a series of random CEPM (scores) that can be modelled into classification techniques. The Multivariate Discriminate Analysis (MDA) classification modelling technique was employed to determine variables that can derive the ideal CEPM. In other words, by finding the most important factors and variables less important variables could be eliminated whilst retaining model robustness.

Clearly it would be inappropriate to assume an equal number of good, average and poor CEPMs. Rather, it was hypothesised that the distribution of CEPMs working in the UK construction industry would follow a roughly normal distribution. That is, a relatively small percentage of CEPM would be classified as being poor whilst a similar percentage would be classified as good; in between these classification would lie the bulk of CEPMs who would be classified as average. This hypothesis is graphically represented in Figure 6.2. It was found that, for example ET*v*3 the most important variable which having the highest ratio represented 27.72 per cent of the enhancement of the good CEPM within the ET*v* Genetic Factor. Also this genetic factor was found the highest ration within whole genetic factors. Based on that, a logical decision was made that this variable will be used in order to distinguish between the groups.

Figure 6.2 Classification Range (Boundary) of each Category.



Because the classification groups of the CEPM are essential to the success of this research project, the *standard deviation* technique was used to distinguish between groups (Anderson *et al.*, 1994). The *standard deviation* of a probability distribution is defined as the square root of the variance σ^2 (Romanovsky *et al.*, 1925). However, variance for example which is important to calculating the standard deviation, for a single variant *x* having a distribution $P(x)$ with known population mean μ, the population variance var (x), commonly also written σ^2, is defined as (refer to formula 6.7)

$$\sigma^2 = \langle (X - \mu)^2 \rangle, \qquad \text{Eq.6.7}$$

Where μ is the population mean and <X> denotes the expectation value. However, for a discrete distribution with *N* possible values of x_i, the population variance is therefore described in formula 6.8 as being:

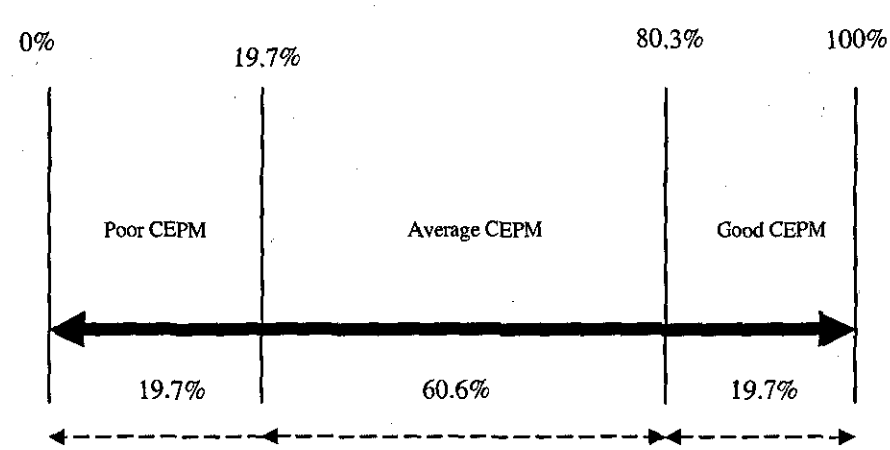
$$\sigma^2 = \sum_{i=1}^{N} P(x_i)(x_i - \mu)^2 \qquad \text{Eq.6.8}$$

The *Standard Deviation* formula is very simple; it is the square root of the variance (σ^2). Refer to formula 6.9):

$$s_{n-1} = \sqrt{\tfrac{1}{N-1}\sum_{I-1}^{N}\left(x_i - x^-\right)^2} \qquad \text{Eq.6.9}$$

By calculating the *standard deviation* for the rating number of ET*v*3 (refer to figure 6.3 it could be determined that the poor CEPM will range between 0% to 19.7%, the average CEPM will range between 19.8% to 80.2% and the good CEPM will be within the 80% to 100 % band width.

Figure 6.3 Category of Classification Boundaries.



6.7 MODELLING AND VALIDATION

Upon completion of the conceptual modelling and data manipulation phase, a more in-depth study of classification techniques and subsequent validation of models derived was required.

The modelling process itself used 75 per cent of the professional questionnaires collected, whilst the remaining 25 per cent was reserved as an hold out validation sample. A comparison could then be made between the two samples to determine whether a significant difference was apparent.

6.7.1 Multivariate Discriminate Analysis

The history of Multivariate Discriminate Analysis (MDA) dates back from 1930s when Fisher (cited from Gupa, 1973) developed a technique to solve classification problem in archaeological findings (Klecka *et al.*, 1980; Schaafsma *et al.*, 1973). MDA has since been utilised in a plethora of research works to: study education testing (Tatsouka and Tiedman *et al.*, 1954); for examining voting behaviour among citizens or legislators (Klecka *et al.*, 1973); studying sex-role behaviour in children (Klecka *et al.*, 1974) and felony court case dispositions (Eisenstein and Jacob, 1977) amongst a wide variety of other problems studied (Klecka *et al.*, 1980).

Within the field of civil and construction engineering, the use of MDA methods have been utilised extensively because it provides a pragmatic solution to many industrial problems. Whilst not exhaustive, examples of applied research using MDA include: contractor creditworthiness evaluation and suppliers debt collection method (Nicholas *et al.*, 2000); hydraulic conductivity of soils (Boadu *et al.*, 2000); highway bridges load capacity reduction with age (Chase *et al.*, 2000); estimation of earthmoving productivity (Smith *et al.*, 1999), assessment of hoisting times of tower cranes (Leung *et al.*, 1999); allocation of construction planning resources (Faniran *et al.*, 1999); analysing highway storm water loads (Irish *et al.*, 1998); seismic design method (Han *et al.*, 1997); traffic flow forecasting (Smith *et al.*, 1997); and prediction of land subsidence due to ground-water use (Mizumura *et al.*, 1994) to name a few.

6.7.2 Fundamental Concepts of MDA

Multivariate Discriminate Analysis (MDA) is primarily used to investigate, evaluate group differences and classify entities into groups, based on known discriminatory variables. Discriminate analysis produces a variate that represents a liner combination of the two (or more) independent variables that will discriminate best between defined groups (Nicholas *et al.*, 2000). The linear combination for a discriminate analysis, also known as the discriminate function, is derived from an equation that can be expressed as (refer to formula 6.10).

The discriminate function has the following form:

$$Z = W_1 x_1 + W_2 x_2 + W_3 x_3 + \dots\dots\dots\dots + W_n x_n \qquad \text{Eq.6.10}$$

Where Z = is the discriminate scope

W_i = is the discriminate weight for a variable

x_i = is the independent variable i

The mathematical requirements, which underlie MDA are: i) number of groups (g); ii) number of discriminating variables (p); iii) number of cases in a group i (n_i); and iv) the total number of cases over all the groups (n). MDA uses a number for predictor variables to classify subjects into two or more distinct groups (Klecka, 1987). The MDA analysis provides a powerful technique for examining differences between two or more groups of objects with respect to several variables simultaneously (ibid). Results of analysis produce an equation or discriminate function where the scores on the predictors are multiplied by a weighting to permit classification of subjects into groups (Ary *et al.*, 1990).

MDA attempts to identify and quantify the linear association between independent variables, thereby classifying them into groups of the dependent variables. MDA has an inherent ability to classify (new) cases into said groups based on the derived MDA functions (models). Linear association is measured via four main statistics namely: i) Eigenvalue (λ) ; ii) Wilks Lambda (Λ); iii) chi-square; and iv) the canonical correlation.

The Eigenvalue: this is the ratio of the between-groups sum of squares, to within-groups sum of squares. Good functions have large Eigenvalue. The Eigenvalue is calculated from: (refer to formula 6.11)

$$\lambda = \frac{ssb}{ssw} = \frac{\sum_{g=1}^{k} Ng(\bar{x_{gi}} - \bar{x_i})(\bar{x_{gj}} - \bar{x_j})}{\sum_{g=1}^{k}\sum_{n=1}^{Ng}(x_{gin} - \bar{x_{gi}})(x_{gjn} - \bar{x_{gj}})} \qquad \text{Eq.6.11}$$

Where λ = the Eigenvalue for the derived MDA function; k is the number of samples of size Ng; x_{gi}^{-} is the i the element of $\bar{X}_g$; $\bar{x}_i$ is mean of x_i and x_{gj}^{-} is the j the element of $\bar{X}_g$.

Wilks Lambda: this is the multi-variate measure of group differences over several variables. (Klecka, 1987). When Wilks Lambda is zero it denotes the group centroids are greatly separated and there are distinct differences between the derived groupings. The formula of derive Wilks Lambda is: (refer to formula 6.12)

$$\Lambda = \prod_{i=k+1}^{q} \cdot \frac{1}{1+\lambda_i} \qquad \text{Eq.6.12}$$

Where Λ is Wilks Lambda; k is the number of functions derived for the MDA in question; λ_i is the value of Eigenvalue for each derived respective function i. and $\prod$ is the individual terms are multiplied together to yield the final product of q terms (Klecka, 1987).

As small value of Lambda is associated with functions that have much variability between groups and little variability within groups (Chase *et al.*, 2000). A Lambda of 1 occurs when the mean of the discriminate scores is the same in all groups and there is no between groups variability (Leung *et al.*, 1999). However, this figure provides little information about the effectiveness of the discriminate function in classification, being mainly a test of the null hypothesis that the population means are equal. Small differences may be statistically significant but this does not permit good discriminate among the groups.

The chi-square statistic: which is the transformation of Wilks Lambda. The chi-square statistic tests the null hypothesis that there is no difference between derived group means (Cooley *et al.*, 1971). The formula to derive the chi-square statistic for the respective discriminate functions is: (refer to formula 6.13).

$$x^2 = -\left[n - \left(\frac{p+g}{2}\right) - 1\right] \log \Lambda_k \qquad \text{Eq. 6.13}$$

Where x^2 is the obtained chi-squared statistic for the derived MDA function; p is the number of discriminating variables; g is the number of groups / leagues the dependent variable is segregated into; and Λ_k is Wilks Lambda for k number of discriminate functions already derived; and n is the total number of cases.

The canonical correlation: this measure considers the utility of the derived discriminate function (Anderson *et al.*, 1948). The canonical correlation is similar to Pearson correlation (Barcikowski *et al.*, 1975), and details the association between the groups and the discriminate function (Dunteman *et al.*, 1989). The canonical correlation ranges from zero to one; one representing one hundred per cent of the total variance being accounted for by the function. The equation for Canonical correlation is provided in formula 6.14:

$$r_i^* = \sqrt{\frac{\lambda_i}{1+\lambda_i}} \qquad \text{Eq.6.14}$$

Where r_i^* is the canonical correlation for the i discriminate function; and λ_i is the Eigenvalue for the i the discriminate function (Leung *et al.*, 1999). For two groups, the canonical correlation is simply the person correlation coefficient between the discriminate score and the group variable (Green *et al.*, 1966).

To group the CEPMs into a particular category of the dependent variable, formula 6.15 was used:

$$D_{kx} = c_1 Y_{1kx} + c_2 Y_{2kx} + c_3 Y_{3kx} + \ldots + c_n Y_{nkx} \qquad \text{Eq.6.15}$$

Where D_{kx} is the dependent variable; i.e. the discriminate score from the canonical discriminate function for case x in group k; Y_{nkx} is the discriminate variable Y_n for case x in group k; and c_n is the discriminate coefficients (Klecka, 1987).

6.8 SUMMARY

This chapter has detailed the methodology that was used for this research work. This research aimed to develop the profile of an optimum CEPM and also simulate average and poor CEPM aptitude. Simulated data would then be used to classify CEPM aptitude (capability) using the MDA technique on 75 per cent of data collected. The remaining 25 per cent of data would be used for model validation purposes. Specifically, consideration was given to how the Likert and Rating scales of the questionnaire would be transformed to allow discursive statistical procedures to be employed and building upon this, determine average and poor classifications. A procedure for determining the importance of individual variables was also described which involved the utilisation of weighting index (*WI*) computation. The formula $WI = 0.5\ IR + 0.5\ RR$ derive the weighting indices of all factors and variables in question. This weighting index formed the basis upon which an equation CEPM classification could be determined. Expressed mathematically the $CEPM = f\,(aPv + bBv + cETv + dMv + eWSv + fQCv + gPLv)$. Within each factor, variables were also derived and the respective weight of each variable was determined.

This chapter also explored the use of other multivariate techniques. However, the decision was taken to use MDA because of its power, ability and excellent track record of use in the construction sector. MDA is also straightforward to use and relatively simple to interpret.

CHAPTER _7_

Data Mining and Exploration

7.0 INTRODUCTION

Data mining of the survey data was essential in order to interpret the data correctly and hence, draw suitable inferences regards to future modelling of the sample data (Gail *et al.*, 1996). In this chapter, analysis of data results derived from the survey will be explored using a variety of statistical analysis methods augmented by discussion. Each generic factor and respective variables within them, were analysed and summarised. The analysis provided a unique understanding of the response data and allowed an in-depth understanding of characteristics that a good CEPM exhibits. These characteristics of the CEPM forms the basic of identifying and classifying their aptitude into good, average and poor classifications for the CEPM. Each of the following sections will now be discussed in further detail:

i. report upon the distribution of respondents;
ii. provides summary analysis of generic factors; and
iii. present an analysis of variables.

7.1 RESPONDENTS REPLY RATE

The research survey obtained a total of 68 returned questionnaires from a random sample targeted of 500 CEPM targeted within the United Kingdom. The response rate was 13.6 % which was a good rate when considering that sample respondents were speculatively targeted. Previous work by Cabahug (2003) revealed that such a strategy will not yield optimum return rate. Although, survey respondents were CEPMs, their level of experience of managing construction and civil engineering projects varied dramatically. Because of this, it was felt that a representative sample of young of old, experienced of inexperienced CEPMs had been sampled.

7.2 ANALYSIS OF GENERIC FACTORS

One of the most important aspects of initial statistical analysis of raw data is to understand data distribution in order to identify whether parametric or non-parametric multivariate techniques should be used. For this research the skewness measure (*sk*) was used to measure of central tendency (Puri *et al.*, 1996).

A fundamental task in many statistical analysis is to *characterise* the location and variability of a data set. For example, the measure of location seeks to estimate a location parameter for distribution i.e. to find a typical or central value that best describes the data distribution. For univariate data, there are three common measures of central tendency, these are: mean, median and mode. The mean is expressed in Formula 7.1:

$$Y^{-} = \sum_{j=1}^{N} \frac{Y_i}{N} \qquad \text{Eq. 7.1}$$

Where Y^{-} is the mean that is sum of the data points divided by the number of the data points. The median equals the middle value and the mode is the most commonly occurring value.

A further characterisation of the data includes skewness (*sk*) and kurtosis (Freeman *et al.*, 1983). A measure of dispersion provides information about the variation of the data set whilst skewness allows the direction of variation to be determined. Consequently, skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the centre point data distribution and can be expressed as Formula 7.1 (Ruddock *et al.*, 1995):

$$sk = \frac{\sum_{j=1}^{N} \left(Y_i - Y^{-}\right)^{s}}{(N-1)s^{s}} \qquad \text{Eq.7.2}$$

where Y^{-} is the mean, s is the standard deviation, and N is the number of data points. Negative values for the skewness indicate data that are skewed left and positive values for the skewness indicate data are skewed right (Rees *et al.*, 1996). Using the *sk* formula, the distribution skewness for each main generic factor was computed and tabulated. For this information, data distribution and skewness can be determined. These observations and findings will subsequently be used for future statistical treatment of skewed data, for example, data transformation procedures and tests of normality such as the Kolmogrov-Smirnov test (Nurosis, 1995; Puri, 1996).

The frequencies of importance rating responses for the main generic factors are presented in Table 7.1. Having identified the skewness measure for the generic factors, the importance rating of generic variables showed the sequence of importance for the variable (refer to Table 7.3 and 7.4). Data observations for importance rating of each generic factors showed that Education and Training (ET*v*) and Planning (PL*v*) factors were rated very important with 61.8 and 54.4 percent score respectively. Project Quality Control (QC*v*), Management (M*v*), Motivation (B*v*) and Personal (P*v*) were rated sometimes important with 33.8, 39.8, 60.3 and 63.2 percent score respectively. It was observed that the Work Situational (WS*v*) factor was rated neither important or not important with 35.3 percent score. It is hypothesised at this juncture that this finding could reveal that due to the transient of construction managers, they are more comfortable with, and less concerned about, their immediate work situation. Future work will be required to confirm (or otherwise) this hypothesis. These findings revealed that ET*v* was rated the highest very important score this prompting additional analysis to determine why?

The frequencies of rank rating of the generic factors are presented in Table 7.2. The rank rating for each factor was also calculated for its skewness characteristic of response distribution using the Formula 7.1 and tabulated in Table 7.4.

The rank rating frequency for the generic factors showed that the following order of importance sequence was observed:

i. Rank rating No. 2 - rET*v* (Education and Training Factor)
ii. Rank rating No. 2 - rPL*v* (Planning Factor)
iii. Rank rating No. 3 – rQC*v* (Project Quality Control Factor)
iv. Rank rating No. 4 - rB*v* (Management Factor)

v. Rank rating No. 4 - rMv (Motivation Factor)

vi. Rank rating No. 4 – rPv (Personal Factor)

vii. Rank rating No. 6 - WSv (Work Situational Factor)

A summary in Table 7.2 illustrates the importance and rank ratings results. It was observed that TEv was ranked 2 (highest order) and rated very important and PLv was ranked 2 as well with rated sometimes important. However, Bv, Mv and Pv were ranked [4] as being in a similar order to their respective importance rating. WSv was noted to be ranked [6] the lowest importance rating. Figure 7.1 and 7.2 shows the similarity between *IR* and *RR*.

A correlation between the *IR* and *RR* was conducted using (2-tailed) Pearson correlation formula (at $p = 0.01$) to determine the degree of association between generic factors (Cohen *et al.*, 2003). Table 7.6 presents the results which range from 0.006 to 0.830; these results revealed a relatively substantial degree of positive correlation between the importance and rank rating of each factor. And also, this provided convincing evidence that agreed with earlier findings derived from analysis.

Figure 7.1 The Similarity Between *IR* and *RR*.

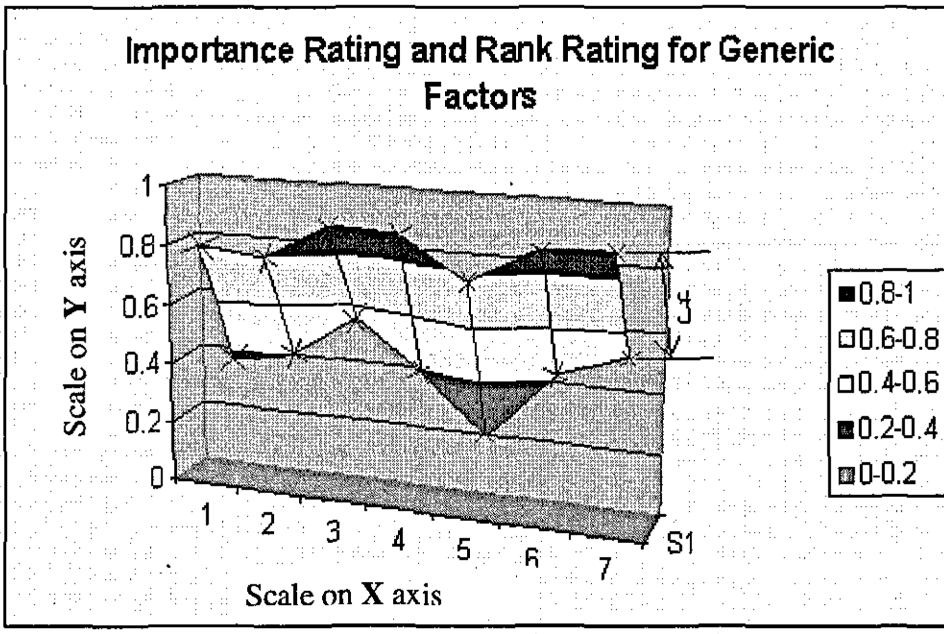


Figure 7.2 The Similarity Between *IR* and *RR*.

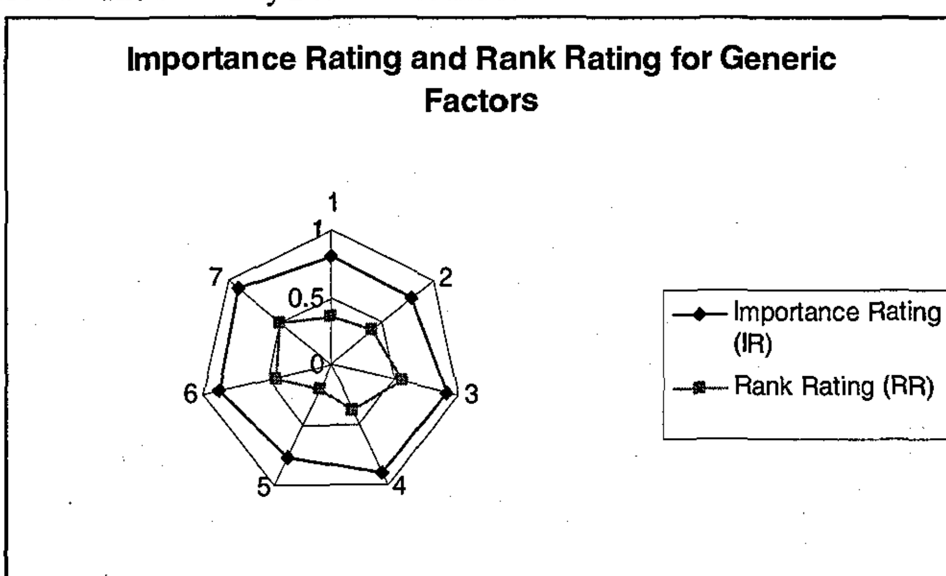


Table7.1 Importance Rating of Generic Factors.

	Frequency of Results Obtained								
	Importance Rating								
	Never important	Often not-important	Neither important or not important	Sometimes important	Very important				
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	**Total number of respondents**	**Mean**	**Median**	**Standard Deviation**
P*v*	0 0 %	0 0 %	11 16.2 %	43 63.2 %	14 20.6 %	68	4.04*	4.00	0.609
B*v*	0 0 %	0 0 %	7 10.3 %	41 60.3 %	20 29.4 %	68	4.19*	4.00	0.605
ET*v*	0 0 %	0 0 %	5 7.4 %	21 30.9 %	42 61.8 %	68	4.54	5.00*	0.633
M*v*	0 0 %	0 0 %	4 5.9 %	27 39.7 %	37 54.4 %	68	4.49*	5.00	0.611
WS*v*	0 0 %	0 0 %	24 35.3 %	36 52.9 %	8 11.8 %	68	3.76*	4.00	0.649
QC*v*	0 0 %	0 0 %	8 11.8 %	23 33.8 %	37 54.4 %	68	4.43*	5.00	0.698
PL*v*	0 0 %	0 0 %	4 5.9 %	27 39.7 %	37 54.4 %	68	4.49*	5.00	0.611

Note: * variables as coded from the CEPM survey questionnaires;
1-2-3-4-5, importance rating -1 never important, 2- often not- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response;

Table 7-1 Rank Rating of Generic Factors.

Factor Code*	Frequency Rank Scale (1-7) 1 [0.14] (%)	2 [0.28] (%)	3 [0.42] (%)	4 [0.57] (%)	5 [0.71] (%)	6 [0.85] (%)	7 [1.0] (%)	Total number of respondents	Mean	Median	Standard Deviation
rP*v*	21 30.9 %	10 14.7 %	2 2.9 %	2 2.9 %	16 23.5 %	8 11.8 %	9 13.2 %	68	4.38*	4.00	2.286
rB*v*	0 0 %	6 8.8 %	16 23.5 %	24 35.3 %	13 19.1 %	9 13.2 %	0 0 %	68	3.96*	4.00	1.152
rET*v*	1 1.5 %	6 8.8 %	5 7.4 %	1 1.5 %	18 26.5 %	6 8.8 %	31 45.6 %	68	2.49*	2.00	1.741
rM*v*	12 17.6 %	2 2.9 %	12 17.6 %	21 30.9 %	2 2.9 %	17 25.0 %	2 2.9 %	68	4.15*	4.00	1.789
rWS*v*	26 38.2 %	21 30.9 %	17 25.0 %	4 5.9 %	0 0 %	0. 0 %	0 0 %	68	6.01*	6.00	0.938
rQC*v*		20 29.4 %	6 8.8 %	8 11.8 %	15 22.1 %	19 27.9 %	0 0 %	68	3.90*	3.50	1.622
rPL*v*	2 2.9 %	0 0 %	14 20.6	12 17.6 %	5 7.4 %	15 22.1 %	20 29.4 %	68	2.90*	2.00	1.703

Note: * variables as coded from the CEPM survey questionnaires;
1-2-3-4-5-6-7, Ranking rate -7 most important, not importance.
[ ]equivalent rank values; Values in parenthesis equates to percentage response;

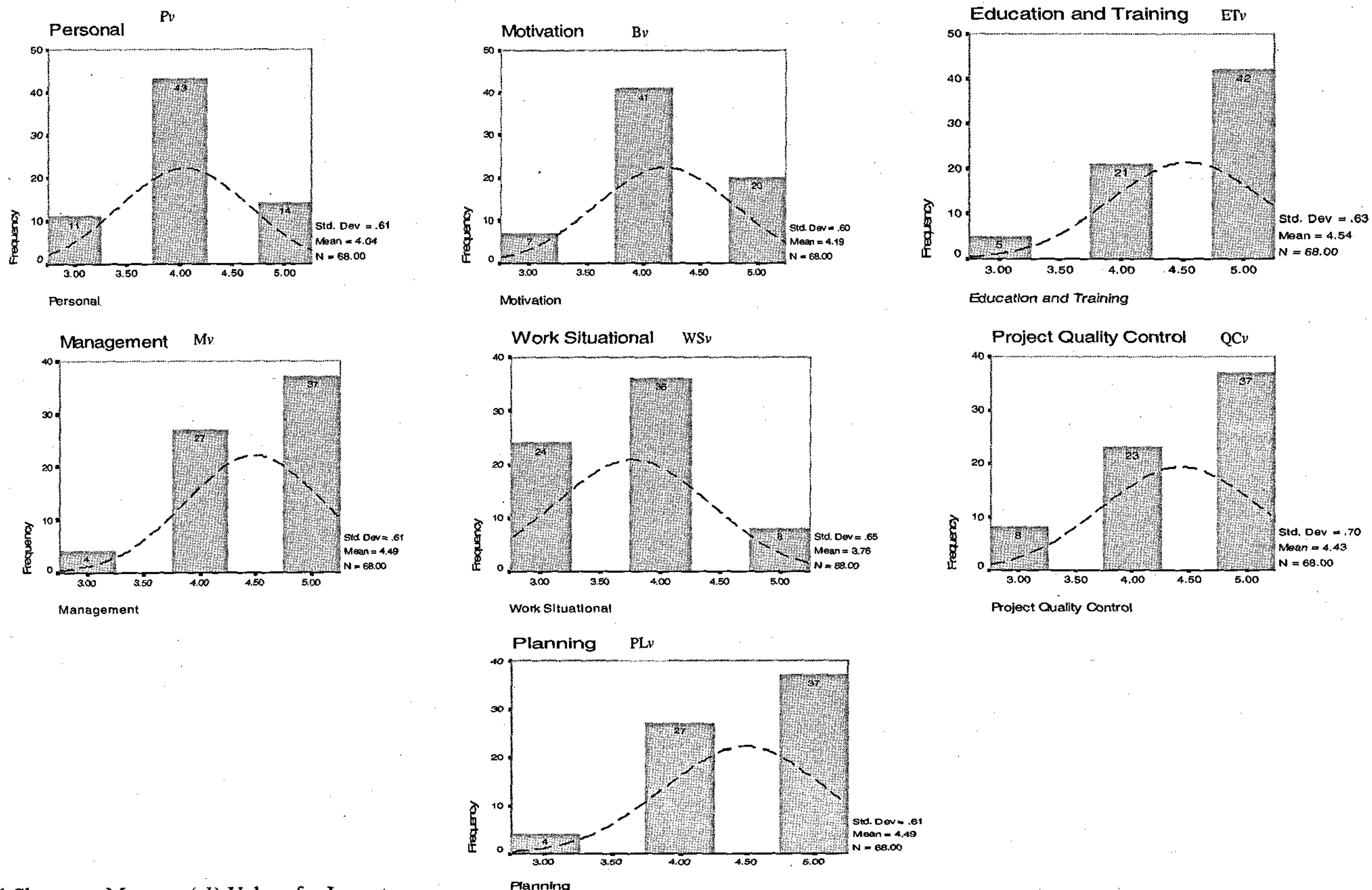


Figure 7-1 Skewness Measure (*sk*) Values for Importance Rating of Generic Factors (*IR*).

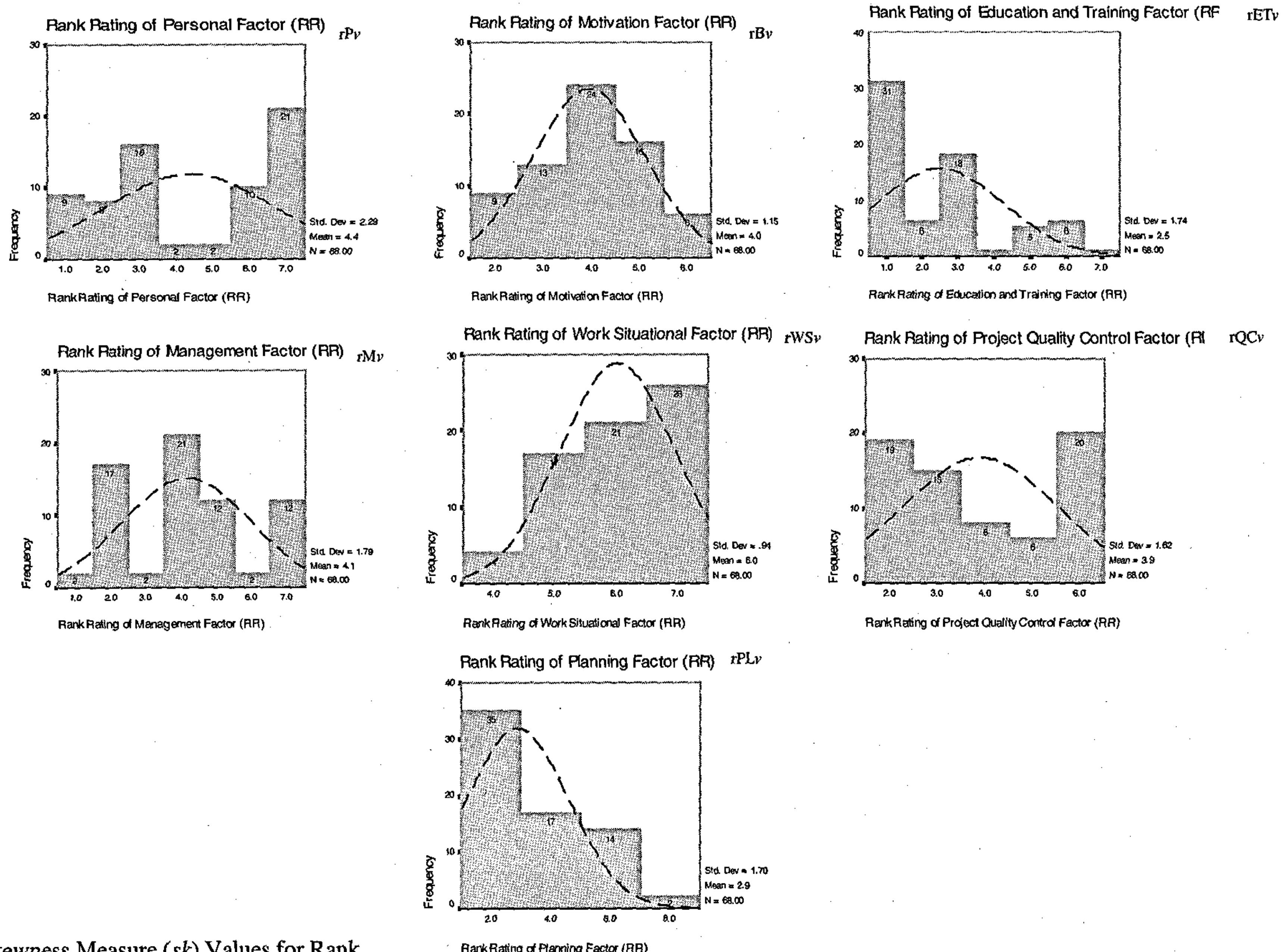


Figure 7-2 Skewness Measure (*sk*) Values for Rank Rating of Generic Factors (*RR*).

Table 7-2 Skewness Measure (*sk*) Values for Importance Rating of Generic Factors.

Generic Factors (Importance Rating)	*sk* Value	Remarks
P*v*	- 0.020	Slightly negatively skewed distribution (use mean values)
B*v*	- 0.107	Slightly negatively skewed distribution (use mean values)
ET*v*	- 1.079	Negatively skewed distribution (use median values) require transformation on the data.
M*v*	- 0.753	Slightly negatively skewed distribution (use mean values)
WS*v*	+ 0.271	Slightly positively skewed distribution (use mean values)
QC*v*	- 0.815	Slightly negatively skewed distribution (use mean values)
PL*v*	- 0.753	Slightly negatively skewed distribution (use mean values)

Table 7.4 Skewness Measure (*sk*) Values for Rank Rating of Generic Factors.

Generic Factors (Rank Rating)	*sk* Value	Remarks
rP*v*	- 0.102	Slightly negatively skewed distribution (use mean values)
rB*v*	- 0.093	Slightly negatively skewed distribution (use mean values)
rET*v*	+ 0.279	Slightly positively skewed distribution (use mean values)
rM*v*	+ 0.175	Slightly positively skewed distribution (use mean values)
rWS*v*	- 0.477	Slightly negatively skewed distribution (use mean values)
rQC*v*	+ 0.193	Slightly positively skewed distribution (use mean values)
rPL*v*	+ 0.427	Slightly positively skewed distribution (use mean values)

Table 7.5 Importance and Rank Rating Results for Generic Factors.

Generic Factors	Importance rating (*IR*)		Rank Rating (*RR*)	
Pv	Sometimes important	0.8088 %	Rank [4]	0.3617 %
Bv	Sometimes important	0.7852 %	Rank [3]	0.4044 %
ETv	Very important	0.9088 %	Rank [2]	0.5514 %
Mv	Sometimes important	0.8970 %	Rank [4]	0.3852 %
WSv	Neither important or not	0.7676 %	Rank [6]	0.1985 %
QCv	Sometimes important	0.8852 %	Rank [3]	0.4292 %
PLv	Very important	0.8970 %	Rank [2]	0.5102 %

Table 7.6 Generic Factors: Correlation between *IR* and *RR*.

Generic Factor	Pearson Correlation Sig. at 0.01 level (2-tailed)
Pv : rPv	0.006
Bv : rBv	0.552
ETv : rETv	0.830
Mv : rMv	0.366
WSv : rWSv	0.064
QCv : rQCv	0.334
PLv : rPLv	0.183

Having analysed data for generic factors, the same analysis of variables within each factor now followed.

7.3 ANALYSIS OF PERSONAL VARIABLES

The ten variables categorised under the Pv variable were analysed to uncover correlation information to determine the strength of relationships between variables. Because each variable in question had two distinctive answers (importance rating and rank ratings), two cases for each variable were considered. The first analysis examined the importance rating whilst the second analysis examined the rank rating. The measure of central tendency used (mean or median) for each variable (for both *IR* or *RR*) was derived from observations of response distribution (skewness measure) using formula 7.1.

7.3.1 Analysis of Importance Rating (*IR*) of Personal Variables

The importance rating of P*v* variables is presented in Table 7.7 while the results emanating from the test for skewness are presented in Table 7.8.

It was observed that the ten variables P*v*1, P*v*2, P*v*3, P*v*4, P*v*5, P*v*6, P*v*7, P*v*8, P*v*9 and P*v*10 distributions were slightly skewed but could be considered within range of normal distribution characteristics. Therefore, mean and standard deviation values could be used for parametric statistical analysis. In such instances, there is no need to conduct transformations of the data to ensure conformance with normality before commencing any statistical classification procedure. Transformation of data would only apply to highly skewed positive or negative distributions.

Analysis revealed that no single personal variable was rated as being very important. It was observed that six variables were rated sometimes important and these variables included intelligence (P*v*6), reliability (P*v*5), dependability (P*v*7), cooperative (P*v*10), flexibility (P*v*9) and personality (P*v*8) with 61.8, 55.9, 47.1, 41.2, 50.0 and 47.1 percent rating respectively. Personal disposition (P*v*4) was rated neither important or not important with 19.1 rating score. The remaining variables were rated often not important. These were: age (P*v*1) with 10.3 rating; and gender (P*v*2) with 22.1 percent rating and marital status (P*v*3) with 20.6 rating.

7.3.2 Analysis of Rank Rating (*RR*) of Personal Variables

The rank rating for personal variables are presented in Table 7.9 while the skewness measure of each variable is presented in Table 7.10. The skewness measure for the marital status (P*v*3) variable was negatively skewed with -1.172 which indicated median values should be utilised. P*v*3 has a median ranking of 9. All the other variables were slightly skewed but can be considered within the normal distribution range. The ranking trends of the personal variable were observed as follows:

Rank 3 - Intelligence (P*v*6);
- Reliability (P*v*5);

Rank 4 - Dependability (P*v*7);
- Personal disposition (P*v*4);

- Cooperative (P*v*10);

Rank 5 - Personality agreeableness (P*v*8);

- Flexibility (P*v*9);

Rank 6 - Age (P*v*1);

Rank 7 - Gender (P*v*2);

- Marital status (P*v*3)

Results reveal that no single variable that can be ranked number 1 and number 2. Interestingly, results do reveal that ranking concurred to an order of sequence similar to the importance rating.

7.3.3 Summary of Importance and Rank Rating Results for Personal Variables.

Table 7.11 summarises the findings of importance and rank ratings. Analysis of personal variables confirmed that similar findings were derived from both the importance and rank rating results. At the same time, Pearson correlation between *IR* and *RR* responses is shown in Table 7.12. A correlation ranging from 0.011 to 0.968 suggested that in some instances there was a substantial degree of correlation between importance and rank ratings of the variables. This means that results observed conformed that the trend of responses was reliable.

Findings also established that P*v*1, P*v*2 and P*v*3 are not important variables to consider for the P*v* factor and therefore do not impact upon CEPM aptitude.

Table 7.7 Importance Rating Results for Personal Variables (Pv).

Variable Code	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
Pv1	8 11.0 %	7 10.3 %	35 51.1 %	17 25.0 %	1 1.5 %	68	2.94*	3.00	0.944
Pv2	12 17.6 %	15 22.1 %	29 42.6 %	12 17.6 %	0 0.00 %	68	2.60*	3.00	0.979
Pv3	21 30.9 %	14 20.6 %	30 44.1 %	1 1.5 %	2 2.9 %	68	2.25*	2.00	1.013
Pv4	0 0.00 %	6 8.8 %	13 19.1 %	25 36.8 %	24 35.3 %	68	3.99*	4.00	0.954
Pv5	0 0.00 %	0 0.00 %	2 2.9 %	38 55.9 %	28 41.2 %	68	4.38*	4.00	0.547
Pv6	0 0.00 %	0 0.00 %	0 0.00 %	42 61.8 %	26 38.2 %	68	4.38*	4.00	0.490
Pv7	0 0.00 %	0 0.00 %	1 1.5 %	32 47.1 %	35 51.5 %	68	4.50*	5.00	0.533
Pv8	0 0.00 %	0 0.00 %	8 11.8 %	35 51.5 %	25 36.8 %	68	4.25*	4.00	0.655
Pv9	0 0.00 %	0 0.00 %	7 10.3 %	34 50.0 %	27 39.7 %	68	4.29*	4.00	0.648
Pv10	0 0.00 %	1 1.5 %	12 17.6 %	28 41.2 %	27 39.7 %	68	4.50*	4.00	0.533

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not-important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.8 Skewness Measure (*sk*) Values for Importance Rating of Personal Variables.

Personal Variables (Importance Rating)	*sk* Value	Remarks
Pv1	- 0.447	Slightly negatively skewed distribution (use mean values)
Pv2	- 0.297	Slightly negatively skewed distribution (use mean values)
Pv3	+ 0.272	Slightly positively skewed distribution (use mean values)
Pv4	- 0.408	Slightly negatively skewed distribution (use mean values)
Pv5	- 0.076	Slightly negatively skewed distribution (use mean values)
Pv6	+ 0.495	Slightly positively skewed distribution (use mean values)
Pv7	- 0.305	Slightly negatively skewed distribution (use mean values)
Pv8	- 0.308	Slightly negatively skewed distribution (use mean values)
Pv9	- 0.370	Slightly negatively skewed distribution (use mean values)
Pv10	- 0.547	Slightly negatively skewed distribution (use mean values)

Table 7.9 Rank Rating Results for Personal Variables (Pv).

Rank Scale (1-10)

Variable Code	1 [0.1] (%)	2 [0.2] (%)	3 [0.3] (%)	4 [0.4] (%)	5 [0.5] (%)	6 [0.6] (%)	7 [0.7] (%)	8 [0.8] (%)	9 [0.9] (%)	10 [1.0] (%)	Total	Mean	Median	Standard Deviation
rPv1	7.4 %	10.3 %	19.1 %	14.7 %	0.0 %	20.6 %	10.3 %	4.4 %	13.2 %	0.0 %	68	6.06*	7.00	2.497
rPv2	15 22.1 %	25 36.8 %	7 10.3 %	0 0.0 %	6 8.8 %	0 0.0 %	0 0.0 %	12 17.6 %	3 4.4 %	0 0.0 %	68	7.49*	9.00	2.729
rPv3	31 45.6 %	10 14.7 %	5 7.4 %	7 10.3 %	0 0.0 %	0 0.0 %	5 7.4 %	8 0.0 %	7 10.3 %	1 4.4 %	68	7.74	9.00*	3.030
rPv4	0 0.0 %	13 19.1 %	10 14.7 %	6 8.8 %	5 7.4 %	2 2.9 %	3 4.4 %	0 0.0 %	0 0.0 %	29 42.6 %	68	4.71*	5.50	3.430
rPv5	0 0.0 %	0 0.0 %	6 8.8 %	7 10.3 %	7 10.3 %	2 2.9 %	8 11.8 %	10 14.7 %	6 8.8 %	22 32.4 %	68	3.60*	3.00	2.475
rPv6	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	10 14.7 %	10 14.7 %	24 35.3 %	4 5.9 %	5 7.4 %	15 22.1 %	68	3.57*	4.00	1.713
rPv7	0 0.0 %	0 0.0 %	8 11.8 %	0 0.0 %	9 13.2 %	13 19.1 %	14 20.6 %	6 8.8 %	18 26.5 %	0 0.0 %	68	4.31*	4.00	1.926
rPv8	7 10.3 %	0 0.0 %	8 11.8 %	6 8.8 %	12 17.6 %	9 13.2 %	9 13.2 %	15 22.1 %	2 2.9 %	0 0.0 %	68	5.56*	5.00	2.282
rPv9	0 0.0 %	0 0.0 %	9 13.2 %	9 13.2 %	13 19.1 %	11 16.2 %	0 0.0 %	23 33.8 %	3 4.4 %	0 0.0 %	68	5.04*	5.00	1.927
rPv10	0 0.0 %	7 10.3 %	4 5.9 %	8 11.8 %	14 20.6 %	7 10.3 %	6 8.8 %	0 0.0 %	15 22.1 %	7 10.3 %	68	4.87*	5.00	2.580

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5-6-7-8-9-10, Ranking rate -10 most important, not important.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.10 Skewness Measure (*sk*) Values for Rank Rating of Personal Variables.

Personal Variables (Importance Rating)	*sk* Value	Remarks
rPv1	- 0.176	Slightly negatively skewed distribution: (use mean values)
rPv2	- 0.762	Slightly negatively skewed distribution: (use mean values)
rPv3	- 1.172	Negatively skewed distribution: (use median values) require transformation on the data.
rPv4	- 0.003	Slightly negatively skewed distribution: (use mean values)
rPv5	+ 0.479	Slightly positively skewed distribution: (use mean values)
rPv6	- 0.312	Slightly negatively skewed distribution: (use mean values)
rPv7	+ 0.462	Slightly positively skewed distribution: (use mean values)
rPv8	+ 0.481	Slightly positively skewed distribution: (use mean values)
rPv9	+ 0.065	Slightly positively skewed distribution: (use mean values)
rPv10	- 0.043	Slightly negatively skewed distribution: (use mean values)

Table 7.11 Importance and Rank Rating Results for Personal Variables.

Personal Variables	Importance rating (IR)	Rank Rating (RR)
Pv 1	Often not important 0.5882 %	Rank [6] 0.4941 %
Pv 2	Often not important 0.5205 %	Rank [7] 0.3382 %
Pv 3	Often not important 0.4500 %	Rank [7] 0.3264 %
Pv 4	Neither important or not 0.7794 %	Rank [4] 0.6294 %
Pv 5	Sometimes important 0.8764 %	Rank [3] 0.7397 %
Pv 6	Sometimes important 0.8764 %	Rank [3] 0.7426 %
Pv 7	Sometimes important 0.900 %	Rank [4] 0.7000 %
Pv 8	Sometimes important 0.8500 %	Rank [5] 0.5441 %
Pv 9	Sometimes important 0.8588 %	Rank [5] 0.5955 %
Pv 10	Sometimes important 0.8382 %	Rank [4] 0.6132 %

Table 7.12 Personal Variables: Correlation between *IR* and *RR*.

Personal Factor	Pearson Correlation Sig. at 0.01 level (2-tailed)
Pv 1 : r Pv 1	0.928
Pv 2 : r Pv 2	0.968
Pv 3 : r Pv 3	0.083
Pv 4 : r Pv 4	0.027
Pv 5 : r Pv 5	0.676
Pv 6 : r Pv 6	0.675
Pv 7 : r Pv 7	0.860
Pv 8 : r Pv 8	0.968
Pv 9 : r Pv 9	0.855
Pv 10 : r Pv 10	0.011

7.4 ANALYSIS OF MOTIVATION VARIABLES

The importance ratings and rank ratings for motivational variables are presented in Tables 7.13 and 7.14 while the skewness measure is presented in Tables 7.15 and 7.16. From the data results observed that job promotion (B*v*6), basic salary (B*v*1), additional bonus payment for output of quality work (B*v*3), team based bonus for timely project completion (Bv4) and additional payment for completing the project on time or early (Bv5) were rated sometimes important with ratings of 33.8, 58.8, 66.2, 54.4 and 54.4 percent respectively.

Table 7.17 presents the rank rating for motivational variables. Rank rating data obtained the following results:

Rank No 2 - Job promotion (B*v*6).
- Additional bonus payment for output of quality work (B*v*3).

Rank No 3 - Basic salary (Bv1).
- Team-based bonus for timely project completion (Bv4).

Rank No 4 - Additional payment for completing the project on time or early (B*v*5).
- Non financial fringe benefits and incentives such as educational opportunities.

The Pearson correlation between IR and RR rating of each variable is shown on Table 7.18 and correlation values range between 0.119 to 0.972. The findings here suggest that a relatively substantial correlation exists between IR and RR rating scores (except for B*v*3 with 0.091).

Table 7.13 Importance Rating Results for Motivation Variables (Bv).

Variable Code	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
Bv1	0 0.0 %	1 1.5 %	0 0.0 %	40 58.8 %	27 39.7 %	68	4.37*	4.00	0.571
Bv2	0 0.0 %	1 1.5 %	10 14.7 %	52 76.5 %	5 7.4 %	68	3.90*	4.00	0.522
Bv3	0 0.0 %	0 0.0 %	9 13.2 %	45 66.2 %	14 20.6 %	68	4.07*	4.00	0.581
Bv4	0 0.00 %	0 0.0 %	13 19.1 %	37 54.4 %	18 26.5 %	68	4.07*	4.00	0.676
Bv5	1 1.5 %	3 4.4 %	7 10.3 %	37 54.4 %	20 29.4 %	68	4.06	4.00*	0.844
Bv6	0 0.00 %	0 0.00 %	8 11.8 %	23 33.8 %	37 54.4 %	68	4.43*	5.00	0.698

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not-important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.14 Rank Rating Results for Motivation Variables (Bv).

Variable Code	Rank Scale (1-6) 1 [0.16] (%)	2 [0.33] (%)	3 [0.5] (%)	4 [0.66] (%)	5 [0.83] (%)	6 [1.0] (%)	Total	Mean	Median	Standard Deviation
rBv1	4 5.9 %	5 7.4 %	13 19.1 %	31 45.6 %	4 5.9 %	11 16.2 %	68	3.13*	3.00	1.315
rBv2	17 25.0 %	23 33.8 %	28 41.2 %	0 0.0 %	0 0.0 %	0 0.0 %	68	4.84*	5.00	0.803
rBv3	7 10.3 %	6 8.8 %	7 10.3 %	13 19.1 %	25 36.8 %	10 14.7 %	68	2.93*	2.00	1.539
rBv4	7 10.3 %	27 39.7 %	7 10.3 %	9 13.2 %	0 0.0 %	18 26.5 %	68	3.68*	4.50	1.807
rBv5	28 41.2 %	0 0.0 %	2 2.9 %	27 39.7 %	11 16.2 %	0 0.0 %	68	4.10*	3.00	1.649
rBv6	5 7.4 %	7 10.3 %	13 19.1 %	0 0.0 %	21 30.7 %	22 32.4 %	68	2.66*	2.00	1.672

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5-6, Ranking rate -6 most important, not important.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.15 Skewness Measure (*sk*) Values for Importance Rating of Motivation Variables.

Motivation Variables (Importance Rating)	*sk* Value	Remarks
B*v*1	- 0.698	Slightly negatively skewed distribution (use mean values)
B*v*2	- 0.786	Slightly negatively skewed distribution (use mean values)
B*v*3	- 0.002	Slightly negatively skewed distribution (use mean values)
B*v*4	- 0.098	Slightly negatively skewed distribution (use mean values)
B*v*5	- 1.186	Negatively skewed distribution: (use median values) require transformation on the data.
B*v*6	- 0.815	Slightly negatively skewed distribution (use mean values)

Table 7.16 Skewness Measure (*sk*) Values for Rank Rating of Motivation Variables.

Motivation Variables (Rank Rating)	*sk* Value	Remarks
rB*v*1	+ 0.155	Slightly positively skewed distribution: (use mean values)
rB*v*2	+ 0.305	Slightly positively skewed distribution: (use mean values)
rB*v*3	+ 0.735	Slightly positively skewed distribution: (use mean values)
rB*v*4	- 0.514	Slightly negatively skewed distribution: (use mean values)
rB*v*5	+ 0.180	Slightly positively skewed distribution: (use mean values)
rB*v*6	+ 0.657	Slightly positively skewed distribution: (use mean values)

Table 7.17 Importance and Rank Rating Results for Motivation Variables.

Motivation Variables	Importance rating (IR)	Rank Rating (RR)
B*v* 1	Sometimes important 0.8764 %	Rank [3] 0.3867 %
B*v* 2	Neither important or not 0.7735 %	Rank [4] 0.2161 %
B*v* 3	Sometimes important 0.8147 %	Rank [2] 0.4073 %
B*v* 4	Sometimes important 0.8147 %	Rank [3] 0.3323 %
B*v* 5	Sometimes important 0.8000 %	Rank [4] 0.2897 %
B*v* 6	Sometimes important 0.8852 %	Rank [2] 0.4338 %

Table 7.18 Motivation Variables: Correlation between *IR* and *RR*.

Motivation Variable	Pearson Correlation Sig. at 0.01 level (2-tailed)
Bv 1 : r Bv 1	0.665
Bv 2 : r Bv 2	0.408
Bv 3 : r Bv 3	0.091
Bv 4 : r Bv 4	0.119
Bv 5 : r Bv 5	0.972
Bv 6 : r Bv 6	0.244

7.5 ANALYSIS OF EDUCATION AND TRAINING VARIABLES

The importance and rank rating for education and training variables are presented in Tables 7.19 and 7.20 while skewness measure for each variable rating and ranking is presented in Tables 7.21 and 7.22 respectively.

Table 7.23 reveals that education and training factor (ET*v*) is the most important factor of all generic factors considered and within this factor four variables were rated sometimes important. These are: practical building knowledge and experience (ET*v*3); specific vocational background (ET*v*2); qualification (ET*v*1); and specific training in project management (ET*v*4) with a rating of 51.5, 32.4, 36.8 and 55.9 percent respectively. The variables continual professional training certificates (ET*v*5) were rated as being neither important or not important with a rating of 25.0 percent score.

Table 7.24 shows the Pearson correlation between *IR* and *RR*. Correlation values ranging between 0.158 to 0.642 suggested a relatively substantial correlation (except for TE*v*5 with 0.009). Such a consistent observation can provide reliable statistical analysis for any future classification procedure of the data.

Table 7.19 Importance Rating Results for Education and Training Variables (ETv).

Variable Code	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	**Total**	**Mean**	**Median**	**Standard Deviation**
ETv1	0 0.0 %	0 0.0 %	12 17.6 %	25 36.8 %	31 45.6 %	68	4.28*	4.00	0.750
ETv2	0 0.0 %	0 0.0 %	13 19.1 %	22 32.4 %	33 48.5 %	68	4.29*	4.00	0.774
ETv3	0 0.0 %	0 0.0 %	3 4.4 %	35 51.5 %	30 44.1 %	68	4.40*	4.00	0.577
ETv4	0 0.00 %	0 0.0 %	8 11.8 %	38 55.9 %	22 32.4 %	68	4.21*	4.00	0.636
ETv5	0 0.0 %	1 1.5 %	17 25.0 %	35 51.5 %	15 22.1 %	68	3.94*	4.00	0.731

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.20 Rank Rating Results for Education and Training Variables (ETv).

Variable Code	Rank Scale (1-5) 1 [0.2] (%)	2 [0.4] (%)	3 [0.6] (%)	4 [0.8] (%)	5 [1.0] (%)	Total	Mean	Median	Standard Deviation
rETv1	7 10.3 %	26 38.2 %	15 22.1 %	13 19.1 %	7 10.3 %	68	3.19*	3.00	1.175
rETv2	28 41.2 %	10 14.7 %	6 8.8 %	20 29.4 %	4 5.9 %	68	3.56*	4.00	1.429
rETv3	0 0.0 %	4 5.9 %	4 5.9 %	13 19.1 %	47 69.1 %	68	1.49	1.00*	0.855
rETv4	5 7.4 %	19 27.9 %	33 48.5 %	11 16.2 %	0 0.0 %	68	3.26*	3.00	0.822
rETv5	24 35.3 %	16 23.5 %	10 14.7 %	13 19.1 %	5 7.4 %	68	3.60*	4.00	1.340

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, Ranking rate -5 most important, not important.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.21 Skewness Measure (*sk*) Values for Importance Rating of Education and Training Variables.

Education &Training Variables (Importance Rating)	*sk* Value	Remarks
ETv1	- 0.513	Slightly negatively skewed distribution (use mean values)
ETv2	- 0.568	Slightly negatively skewed distribution (use mean values)
ETv3	- 0.304	Slightly negatively skewed distribution (use mean values)
ETv4	- 0.200	Slightly negatively skewed distribution (use mean values)
ETv5	- 0.145	Slightly negatively skewed distribution (use mean values)

Table 7.22 Skewness Measure (*sk*) Values for Rank Rating of Education and Training Variables.

Education &Training Variables (Importance Rating)	*sk* Value	Remarks
rETv1	- 0.384	Slightly negatively skewed distribution: (use mean values)
rETv2	- 0.312	Slightly negatively skewed distribution: (use mean values)
rETv3	+ 1.818	Positively skewed distribution: (use median values) require transformation on the data.
rETv4	+ 0.300	Slightly positively skewed distribution: (use mean values)
rETv5	- 0.495	Slightly negatively skewed distribution: (use mean values)

Table 7.23 Importance and Rank Rating Results for Education and Training Variables.

Education &Training Variables	Importance rating (IR)		Rank Rating (RR)
ETv 1	Sometimes important	0.8558 %	Rank [3] 0.2808 %
ETv 2	Sometimes important	0.8588 %	Rank [3] 0.2441 %
ETv 3	Sometimes important	0.8794 %	Rank [1] 0.4382 %
ETv 4	Sometimes important	0.8411 %	Rank [3] 0.2735 %
ETv 5	Neither important or not	0.7882 %	Rank [3] 0.2397 %

Table 7.24 Education and Training Variables: Correlation between *IR* and *RR*.

Education and Training Variable	Pearson Correlation Sig. at 0.01 level (2-tailed)
ETv 1 : r ETv 1	0.549
ETv 2 : r ETv 2	0.158
ETv 3 : r ETv 3	0.642
ETv 4 : r ETv 4	0.446
ETv 5 : r ETv 5	0.009

7.6 ANALYSIS OF MANAGEMENT VARIABLES

The importance and rank rating for management variables are presented in Tables 7.25 and 7.26 while the skewness measure for each variable rating and ranking is presented in Tables 7.27 and 7.28 respectively. With reference to skewness measures cited in Table 7.4, the measure of central tendency of each variable is observed in Table 7.29. Importance rating results revealed that two variables were rated very important, nine variables were rated as being sometimes important and two variables were rated as being neither important or not important. Mv2 (authority to deal with people or problems as they occur) was ranked highest (ranked 2). Mv10 (the ability to supervise personnel on site) was ranked lowest (ranked 10).

Table 7.30 shows the Pearson correlation of *IR* and *RR*. Correlation values ranging from 0.249 to 0.909 suggested a relatively substantial correlation (except for Mv9 and Mv10 with 0.062 and 0.072 respectively). Such consistent observations can provide reliable statistical analysis for future classification procedure of the data.

Table 7.25 Importance Rating Results for Management Variables (Mv).

Variable Code	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
Mv1	0 0.0 %	0 0.0 %	7 10.3 %	42 61.8 %	19 27.9 %	68	4.18*	4.00	0.597
Mv2	0 0.0 %	0 0.0 %	3 4.4 %	25 36.8 %	40 58.8 %	68	4.54*	5.00	0.584
Mv3	0 0.0 %	1 1.5 %	5 7.1 %	36 52.9 %	26 38.2 %	68	4.28*	4.00	0.666
Mv4	0 0.00 %	1 1.5 %	3 4.4 %	11 16.2 %	53 77.9 %	68	4.71	5.00*	0.624
Mv5	0 0.0 %	1 1.5 %	6 8.8 %	22 32.4 %	39 57.4 %	68	4.46	5.00*	0.721
Mv6	1 1.5 %	0 0.0 %	3 4.4 %	31 45.6 %	33 48.5 %	68	4.40	4.00*	0.715
Mv7	0 0.0 %	0 0.0 %	5 7.4 %	39 57.4 %	24 35.3 %	68	4.28*	4.00	0.595
Mv8	0 0.0 %	0 0.0 %	9 13.2 %	34 50.0 %	25 36.8 %	68	4.24*	4.00	0.672
Mv9	0 0.0 %	2 2.9 %	8 11.8 %	32 47.1 %	26 38.2 %	68	4.21*	4.00	0.764
Mv10	0 0.0 %	0 0.0 %	7 10.3 %	21 30.9 %	40 58.8 %	68	4.49*	5.00	0.680
Mv11	0 0.0 %	5 7.4 %	18 26.5 %	28 41.2 %	17 25.0 %	68	3.84*	4.00	0.891
Mv12	0 0.0 %	2 2.9 %	7 10.3 %	42 61.8 %	17 25.0 %	68	4.09*	4.00	0.685
Mv13	2 2.9 %	4 5.9 %	15 22.1 %	34 50.0 %	13 19.1 %	68	3.76*	4.00	0.932

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.26 Rank Rating Results for Management Variables (Mv).

Variable Code	Rank Scale (1-13)																
	1 [0.071] (%)	2 [0.15] (%)	3 [0.23] (%)	4 [0.30] (%)	5 [0.38] (%)	6 [0.46] (%)	7 [0.53] (%)	8 [0.61] (%)	9 [0.69] (%)	10 [0.76] (%)	11 [0.84] (%)	12 [0.92] (%)	13 [1.0] (%)	Total	Mean	Median	Standard Deviation
Mv1	4 5.9 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	2 2.9 %	0 0.0 %	0 0.0 %	5 7.4 %	12 17.6 %	15 22.1 %	7 10.3 %	23 33 8 %	68	3.28	3.00*	2.931
Mv2	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	3 4.4 %	11 16.2 %	6 8.8 %	0 0.0 %	34 50 %	14 20.6 %	68	2.63*	2.00	1.535
Mv3	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	8 11.8 %	0 0.0 %	0 0.0 %	14 20.6 %	19 27.9 %	15 22.1 %	5 7.4 %	2 2.9 %	5 7.4 %	68	4.93*	5.00	2.025
Mv4	0 0.0 %	4 5.9 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	13 19.1 %	0 0.0 %	7 10.3 %	15 22.1 %	7 10.3 %	9 13.2 %	13 19.1 %	68	4.21	4.00*	2.831
Mv5	0 0.0 %	0 0.0 %	7 10.3 %	0 0.0 %	0 0.0 %	0 0.0 %	0 0.0 %	7 10.3 %	21 30.9 %	0 0.0 %	20 29.4 %	9 13.2 %	4 5.9 %	68	4.50	5.00*	2.640
Mv6	6 8.8 %	0 0.0 %	0 0.0 %	8 11.8 %	0 0.0 %	7 10.3 %	2 2.9 %	24 35.3 %	5 7.4 %	0 0.0 %	9 13.2 %	3 4.4 %	4 5.9 %	68	6.38*	6.00	3.177
Mv7	0 0.0 %	6 8.8 %	4 5.9 %	0 0.0 %	12 17.6 %	7 10.3 %	12 17.6 %	3 4.4 %	0 0.0 %	0 0.0 %	15 22.1 %	4 5.9 %	5 7.4 %	68	6.47*	7.00	3.397
Mv8	0 0.0 %	5 7.4 %	6 8.8 %	0 0.0 %	4 5.9 %	22 32.4 %	4 5.9 %	4 5.9 %	3 4.4 %	8 11.8 %	7 10.3 %	5 7.4 %	0 0.0 %	68	6.88*	8.00	2.950
Mv9	4 5.9 %	17 25.0 %	0 0.0 %	11 16.2 %	2 2.9 %	10 14.7 %	7 10.3 %	0 0.0 %	0 0.0 %	7 10.3 %	3 4.4 %	7 10.3 %	0 0.0 %	68	8.29*	8.50	3.579
Mv10	0 0.0 %	7 10.3 %	15 22.1 %	17 25.0 %	0 0.0 %	4 5.9 %	11 16.2 %	6 8.8 %	0 0.0 %	0 0.0 %	0 0.0 %	3 4.4 %	5 7.4 %	68	8.46	10.00*	3.206
Mv11	8 11.8 %	7 10.3 %	2 2.9 %	2 2.9 %	30 44.1 %	4 5.9 %	3 4.4 %	5 7.4 %	0 0.0 %	0 0.0 %	0 0.0 %	7 10.3 %	0 0.0 %	68	8.78*	9.00	2.997
Mv12	9 13.2 %	2 2.9 %	15 22.1 %	11 16.2 %	4 5.9 %	6 8.8 %	5 7.4 %	0 0.0 %	5 7.4 %	0 0.0 %	0 0.0 %	0 0.0 %	11 16.2 %	68	8.40*	10.00	3.898
Mv13	10 14.7 %	10 14.7 %	11 16.2 %	4 5.9 %	0 0.0 %	5 7.4 %	11 16.2 %	5 7.4 %	2 2.9 %	10 14.7 %	0 0.0 %	0 0.0 %	0 0.0 %	68	8.94*	10.00	3.171

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5-6-7-8-9-10-11-12-13, Ranking rate -13 most important, not importance.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.27 Skewness Measure (*sk*) Values for Importance Rating of Management Variables.

Management Variables (Importance Rating)	*sk* Value	Remarks
Mv1	- 0.074	Slightly negatively skewed distribution (use mean values)
Mv2	- 0.870	Slightly negatively skewed distribution (use mean values)
Mv3	- 0.697	Slightly negatively skewed distribution (use mean values)
Mv4	- 2.352	Negatively skewed distribution: (use median values) require transformation on the data.
Mv5	- 1.193	Negatively skewed distribution: (use median values) require transformation on the data.
Mv6	- 1.769	Negatively skewed distribution: (use median values) require transformation on the data.
Mv7	- 0.171	Slightly negatively skewed distribution (use mean values)
Mv8	- 0.316	Slightly negatively skewed distribution (use mean values)
Mv9	- 0.784	Slightly negatively skewed distribution (use mean values)
Mv10	- 0.972	Slightly negatively skewed distribution (use mean values)
Mv11	- 0.323	Slightly negatively skewed distribution (use mean values)
Mv12	- 0.687	Slightly negatively skewed distribution (use mean values)
Mv13	- 0.873	Slightly negatively skewed distribution (use mean values)

Table 7.28 Skewness Measure (*sk*) Values for Rank Rating of Management Variables.

Management Variables (Importance Rating)	*sk* Value	Remarks
rMv1	+2.214	Positively skewed distribution: (use median values) require transformation on the data.
rMv2	+ 0.878	Slightly positively skewed distribution: (use mean values)
rMv3	+ 0.292	Slightly positively skewed distribution: (use mean values)
rMv4	+ 1.114	Positively skewed distribution: (use median values) require transformation on the data.
rMv5	+ 1.311	Positively skewed distribution: (use median values) require transformation on the data.
rMv6	+ 0.436	Slightly positively skewed distribution: (use mean values)
rMv7	- 0.077	Slightly negatively skewed distribution: (use mean values)
rMv8	- 0.029	Slightly negatively skewed distribution: (use mean values)
rMv9	- 0.477	Slightly negatively skewed distribution: (use mean values)
rMv10	- 1.111	Negatively skewed distribution: (use median values) require transformation on the data.
rMv11	- 0.826	Slightly negatively skewed distribution: (use mean values)
rMv12	- 0.877	Slightly negatively skewed distribution: (use mean values)
rMv13	- 0.234	Slightly negatively skewed distribution: (use mean values)

Table 7.29 Importance and Rank Rating Results for Management Variables.

Management Variables	Importance rating (IR)		Rank Rating (RR)	
Mv 1	Sometimes important	0.8352 %	Rank [3]	1.072 %
Mv 2	Sometimes important	0.9088 %	Rank [2]	1.1367 %
Mv 3	Sometimes important	0.8558 %	Rank [4]	0.9073 %
Mv 4	Very important	0.9411 %	Rank [4]	0.9794 %
Mv 5	Very important	0.8911 %	Rank [5]	0.9500 %
Mv 6	Sometimes important	0.8823 %	Rank [6]	0.7617 %
Mv 7	Sometimes important	0.8558 %	Rank [6]	0.7529 %
Mv 8	Sometimes important	0.8470 %	Rank [6]	0.7044 %
Mv 9	Sometimes important	0.8411 %	Rank [8]	0.5705 %
Mv 10	Very important	0.8970 %	Rank [10]	0.5544 %
Mv 11	Neither important or not	0.7676 %	Rank [8]	0.5220%
Mv 12	Sometimes important	0.8470 %	Rank [8]	0.5602 %
Mv 13	Neither important or not	0.7470 %	Rank [8]	0.5058 %

Table 7.30 Management Variables: Correlation between *IR* and *RR*.

Management Factor	Pearson Correlation Sig. at 0.01 level (2-tailed)
Mv 1 : r Mv 1	0.871
Mv 2 : r Mv 2	0.256
Mv 3 : r Mv 3	0.256
Mv 4 : r Mv 4	0.456
Mv 5 : r Mv 5	0.102
Mv 6 : r Mv 6	0.902
Mv 7 : r Mv 7	0.592
Mv 8 : r Mv 8	0.909
Mv 9 : r Mv 9	0.062
Mv 10 : r Mv 10	0.072
Mv 11 : r Mv 11	0.287
Mv 12 : r Mv 12	0.249
Mv 13 : r Mv 13	0.840

7.7 ANALYSIS OF WORK SITUATIONAL VARIABLES

The importance and rank rating for work situational variables are presented in Tables 7.31 and 7.32 while the skewness measure for each variables rating and ranking is presented in Tables 7.33 and 7.34 respectively.

With reference to the skewness measures in Table 7.4, the measure of central tendency of each variable is observed in Table 7.35. Importance rating results revealed that no variable was rated as being very important within this generic factor. However, five variables were rated as being sometimes important WSv5, WSv4, WSv7, WSv6 and WSv3. Two variables were rated as being neither important or not important WSv1 and WSv2. Consequently, WS*v*5 was ranked highest (ranked 2) and WSv1 was ranked lowest (ranked 5).

Table 7.36 shows the Pearson correlation of *IR* and *RR*. Correlation values range between 0.119 to 0.967 and suggest that a relatively substantial correlation (except for WS*v*6 0.022) exists between IR and RR rating scores. Such consistent observations provide reliable statistical analysis for future classification procedure of these data results.

Table 7.31 Importance Rating Results for Work Situational Variables (WSv).

Variable Code*	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
WSv1	2 2.9 %	11 16.2 %	28 41.2 %	20 29.4 %	7 10.3 %	68	3.28*	3.00	0.960
WSv2	0 0.0 %	0 0.0 %	13 19.1 %	45 66.2 %	10 14.7 %	68	3.96*	4.00	0.584
WSv3	0 0.0 %	0 0.0 %	14 20.6 %	29 42.6 %	25 36.8 %	68	4.16*	4.00	0.745
WSv4	0 0.00 %	0 0.0 %	10 14.7 %	24 35.3 %	34 50.0 %	68	4.35*	4.50	0.728
WSv5	0 0.0 %	0 0.0 %	8 11.8 %	27 39.7 %	33 48.5 %	68	4.37*	4.00	0.689
WSv6	1 1.5 %	0 0.0 %	6 8.8 %	40 58.8 %	22 32.4 %	68	4.24*	4.00	0.601
WSv7	0 0.0 %	0 0.0 %	9 13.2 %	30 44.1 %	29 42.6 %	68	4.29*	4.00	0.692

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 *never important*, 2- *often not*- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.32 Rank Rating Results for Work Situational Variables (WSv).

Variable Code	Rank Scale (1-7) 1 [0.14] (%)	2 [0.28] (%)	3 [0.42] (%)	4 [0.57] (%)	5 [0.71] (%)	6 [0.85] (%)	7 [1.0] (%)	Total	Mean	Median	Standard Deviation
WSv1	23 33.8 %	15 22.1 %	7 10.3 %	8 11.8 %	10 14.7 %	0 0.0 %	5 7.4 %	68	5.19*	6.00	1.863
WSv2	25 0.0 %	1 0.0 %	11 0.0 %	20 0.0 %	7 0.0 %	4 0.0 %	0 0.0 %	68	5.07*	5.00	1.660
WSv3	0 0.0 %	16 23.5 %	3 4.4 %	5 7.4 %	12 17.6 %	19 27.9 %	13 19.1 %	68	3.21*	3.00	1.849
WSv4	7 10.3 %	8 11.8 %	12 17.6 %	2 2.9 %	18 26.5 %	4 5.9 %	17 25.0 %	68	3.59*	3.00	2.053
WSv5	0 0.0 %	8 11.8 %	10 14.7 %	0 0.0 %	12 17.6 %	20 29.4 %	18 26.5 %	68	2.82*	2.00	1.736
WSv6	6 8.8 %	14 20.6 %	20 29.4 %	17 25.0 %	7 10.3 %	8 11.8 %	2 2.9 %	68	4.28*	4.50	1.381
WSv7	12 17.6 %	4 5.9 %	7 10.3 %	20 29.4 %	2 2.9 %	15 22.1 %	8 11.8 %	68	3.93*	4.00	1.987

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5-6-7, Ranking rate -7 most important,6,5, 4,3,2,1 getting lesser importance.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.33 Skewness Measure (*sk*) Values for Importance Rating of Work Situational Variables.

Work situational variables (Importance Rating)	*sk* Value	Remarks
WSv1	- 0.073	Slightly negatively skewed distribution (use mean values)
WSv2	+ 0.003	Slightly positively skewed distribution (use mean values)
WSv3	- 0.273	Slightly negatively skewed distribution (use mean values)
WSv4	- 0.661	Slightly negatively skewed distribution (use mean values)
WSv5	- 0.633	Slightly positively skewed distribution (use mean values)
WSv6	- 0.141	Slightly negatively skewed distribution (use mean values)
WSv7	- 0.467	Slightly negatively skewed distribution (use mean values)

Table 7.34 Skewness Measure (*sk*) Values for Rank Rating of Work Situational Variables.

Work situational variables (Importance Rating)	*sk* Value	Remarks
rWSv1	- 0.815	Slightly negatively skewed distribution (use mean values)
rWSv2	- 0.080	Slightly negatively skewed distribution (use mean values)
rWSv3	+ 0.476	Slightly positively skewed distribution (use mean values)
rWSv4	+ 0.195	Slightly positively skewed distribution (use mean values)
rWSv5	+ 0.703	Slightly positively skewed distribution (use mean values)
rWSv6	- 0.593	Slightly negatively skewed distribution (use mean values)
rWSv7	+ 0.163	Slightly positively skewed distribution (use mean values)

Table 7.35 Importance and Rank Rating Results for Work Situational Variables.

Work situational variables	Importance rating (IR)		Rank Rating (RR)	
WSv1	Neither important or Not	0.6558 %	Rank [5]	0.2808 %
WSv2	Neither important or Not	0.7911 %	Rank [5]	0.2926 %
WSv3	Sometimes important	0.8323 %	Rank [3]	0.4794 %
WSv4	Sometimes important	0.8705 %	Rank [3]	0.4411 %
WSv5	Sometimes important	0.8735 %	Rank [2]	0.5176 %
WSv6	Sometimes important	0.8470 %	Rank [4]	0.3720 %
WSv7	Sometimes important	0.8588 %	Rank [3]	0.4073 %

Table 7.36 Work Situational Variables: Correlation between *IR* and *RR*.

Work situational variables	Pearson Correlation Sig. at 0.01 level (2-tailed)
WSv1: rWSv1	0.654
WSv2: rWSv2	0.782
WSv3: rWSv3	0.615
WSv4: rWSv4	0.119
WSv5: rWSv5	0.967
WSv6: rWSv6	0.022
WSv7: rWSv7	0.120

7.8 ANALYSIS OF QUALITY CONTROL VARIABLES

The importance and rank rating for quality control variables are presented in Tables 7.37 and 7.38 while the skewness measure for each variable rating and ranking is presented in Tables 7.39 and 7.40 respectively.

Results revealed that no one variable was rated as being very important. It was observed that seven variables were rated sometimes important and these included: creating a quality management plan to deliver promised value (QCv3); translating expectations into specific deliverables to meet customer requirements (QCv4); maintaining project quality control, correcting deviations and avoiding defect reoccurrence (QC*v*6); planning general alternatives for any contingency that may arise (QC*v*8); employing quality assurance processes, tools and metrics (QC*v*5); including all project partners (QC*v*7); and ensuring project quality in order to achieve customer satisfaction (QC*v*1). Establishing a quality-centred environment among project stakeholders (QC*v*2) was rated neither important or not important.

Table 7.42 shows the Pearson correlation between *IR* and *RR*. Correlation values ranged between 0.175 to 0.975 and suggested that a relatively substantial correlation between IR and RR rating scores exists. Such a consistent observation provided reliable statistical analysis for future classification procedure of these data results.

Table 7.37 Importance Rating Results for Quality Control Variables (QCv).

Variable Code*	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
QCv1	1 1.5 %	1 1.5 %	2 2.9 %	33 48.5 %	31 45.6 %	68	4.35	4.00*	0.748
QCv2	0 0.0 %	2 2.9 %	14 20.6 %	40 58.8 %	12 17.6 %	68	3.91*	4.00	0.707
QCv3	0 0.0 %	0 0.0 %	8 11.8 %	39 57.4 %	21 30.9 %	68	4.19*	4.00	0.629
QCv4	0 0.00 %	1 1.5 %	8 11.8 %	39 57.4 %	20 29.4 %	68	4.15*	4.50	0.675
QCv5	0 0.0 %	1 1.5 %	19 27.9 %	24 35.3 %	24 35.3 %	68	4.03*	4.00	0.880
QCv6	1 1.5 %	2 2.9 %	17 25.0 %	16 23.5 %	32 47.1 %	68	4.12*	4.00	0.985
QCv7	0 0.0 %	5 7.4 %	3 4.4 %	40 58.8 %	20 29.4 %	68	4.10	4.00*	0.794
QCv8	0 0.0 %	3 4.4 %	10 14.7 %	31 45.6 %	24 35.3 %	68	4.12*	4.00	0.820

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.38 Rank Rating Results for Quality Control Variables (QCv).

Variable Code	Rank Scale (1-8) 1 [0.12] (%)	2 [0.25] (%)	3 [0.37] (%)	4 [0.5] (%)	5 [0.62] (%)	6 [0.75] (%)	7 [0.67] (%)	8 [1.0] (%)	**Total**	**Mean**	**Median**	**Standard Deviation**
QCv1	0 0.0 %	7 10.3 %	11 16.2 %	9 13.2 %	10 14.7 %	9 13.2 %	5 7.4 %	22 32.4 %	68	3.66*	4.00	2.169
QCv2	19 27.9 %	3 4.4 %	6 8.8 %	9 13.2 %	20 29.4 %	4 5.9 %	2 2.9 %	5 7.4 %	68	5.22*	5.00	2.184
QCv3	0 0.0 %	23 33.8 %	3 4.4 %	5 7.4 %	7 10.3 %	16 23.5 %	7 10.3 %	7 10.3 %	68	4.43*	4.00	2.181
QCv4	0 0.0 %	8 11.8 %	21 30.9 %	10 14.7 %	9 13.2 %	5 7.4 %	15 22.1 %	0 0.0 %	68	4.60*	5.00	1.755
QCv5	7 10.3 %	7 10.3 %	7 10.3 %	6 8.8 %	5 7.4 %	0 0.0 %	23 33.8 %	13 19.1 %	68	3.76*	2.00	2.486
QCv6	7 10.3 %	6 8.8 %	6 8.8 %	21 30.9 %	0 0.0 %	14 20.6 %	8 11.8 %	6 8.8 %	68	4.46*	5.00	2.105
QCv7	18 26.5 %	9 13.2 %	5 7.4 %	0 0.0 %	7 10.3 %	10 14.7 %	11 16.2 %	8 11.8 %	68	4.78*	4.00	2.659
QCv8	18 26.5 %	7 10.3 %	8 11.8 %	13 19.1 %	10 14.7 %	10 14.7 %	2 2.9 %	0 0.0 %	68	5.59*	5.00	1.902

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, Ranking rate -8 most important, not importance.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.39 Skewness Measure (*sk*) Values for Importance Rating of Quality Control Variables.

Quality control variables (Importance Rating)	*sk* Value	Remarks
QCv1	- 1.787	Negatively skewed distribution: (use median values) require transformation on the data.
QCv2	+ 0.396	Slightly positively skewed distribution (use mean values)
QCv3	- 0.166	Slightly negatively skewed distribution (use mean values)
QCv4	- 0.484	Slightly negatively skewed distribution (use mean values)
QCv5	- 0.599	Slightly negatively skewed distribution (use mean values)
QCv6	- 0.821	Slightly negatively skewed distribution (use mean values)
QCv7	- 1.108	Negatively skewed distribution: (use median values) require transformation on the data.
QCv8	- 0.725	Slightly negatively skewed distribution (use mean values)

Table 7.40 Skewness Measure (*sk*) Values for Rank Rating of Quality Control Variables.

Quality control variables (Importance Rating)	*sk* Value	Remarks
rQCv1	+ 0.008	Slightly positively skewed distribution (use mean values)
rQCv2	- 0.141	Slightly negatively skewed distribution (use mean values)
rQCv3	- 0.035	Slightly negatively skewed distribution (use mean values)
rQCv4	- 0.339	Slightly negatively skewed distribution (use mean values)
rQCv5	+ 0.457	Slightly positively skewed distribution (use mean values)
rQCv6	+ 0.044	Slightly positively skewed distribution (use mean values)
rQCv7	+ 0.015	Slightly positively skewed distribution (use mean values)
rQCv8	+ 0.080	Slightly positively skewed distribution (use mean values)

Table 7.41 Importance and Rank Rating Results for Quality Control Variables.

Quality control variables	Importance rating (IR)		Rank Rating (RR)	
QCv1	Sometimes important	0.8705 %	Rank [3]	0.5338 %
QCv2	Neither important or Not	0.7823 %	Rank [5]	0.3779 %
QCv3	Sometimes important	0.8382 %	Rank [4]	0.4573 %
QCv4	Sometimes important	0.8294 %	Rank [4]	0.4397 %
QCv5	Sometimes important	0.8088 %	Rank [3]	0.5235 %
QCv6	Sometimes important	0.8235 %	Rank [4]	0.4544 %
QCv7	Sometimes important	0.8205 %	Rank [4]	0.4220 %
QCv8	Sometimes important	0.8235 %	Rank [5]	0.3411 %

Table 7.42 Quality Control Variables: Correlation between *IR* and *RR*.

Quality control variables	Pearson Correlation Sig. at 0.01 level (2-tailed)
QCv1: rQCv1	0.175
QCv2: rQCv2	0.282
QCv3: rQCv3	0.506
QCv4: rQCv4	0.359
QCv5: rQCv5	0.255
QCv6: rQCv6	0.250
QCv7: rQCv7	0.975
QCv8: rQCv8	0.572

7.9 ANALYSIS OF PLANNING VARIABLES

The importance and rank rating for planning variables are presented in Tables 7.43 and 7.44 while the skewness measure for each variable's rating and ranking is presented in Tables 7.45 and 7.46 respectively.

Table 7.47 reveals that for the planning factor (PLv) (which is the second most importance factor within the whole generic factors) all variables were rated sometimes important. Variables are: scheduling key project activities at completion of the project design phase (PLv1); recognition of the interdependence of the project activities (PLv2); identifying any critical items to the project's success early (PLv3); seeking the best cost estimates for works undertaken (PL*v*4); quality materials selection and storage of these on site (PL*v*5); and selection of appropriate plant and equipment (PL*v*6), and. As shown in Table 7.47 that PL*v*1 was ranked highest (ranked2) and PL*v*6 was ranked lowest (ranked 4).

Table 7.48 shows the Pearson correlation between the *IR* and *RR*. Correlation values ranging between 0.242 to 0.807 suggest that a relatively substantial correlation (except for PL*v*3 with 0.013) between IR and RR rating scores. Such a consistent observation can provide reliable statistical analysis for future classification procedure of these data results.

Table 7.43 Importance Rating Results for Planning Variables (PLv).

Variable Code*	Frequency 1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total	Mean	Median	Standard Deviation
PLv1	0 0.0 %	2 2.9 %	9 13.2 %	28 41.2 %	29 42.6 %	68	4.24*	4.00	0.794
PLv2	0 0.0 %	1 1.5 %	6 8.8 %	29 42.6 %	32 47.1 %	68	4.35*	4.00	0.707
PLv3	0 0.0 %	0 0.0 %	3 4.4 %	26 38.2 %	39 57.4 %	68	4.53*	5.00	0.585
PLv4	0 0.00 %	2 2.9 %	6 8.8 %	39 57.4 %	21 30.9 %	68	4.16*	4.00	0.704
PLv5	1 1.5 %	0 0.0 %	7 10.3 %	33 48.5 %	27 39.7 %	68	4.25	4.00*	0.760
PLv6	0 0.0 %	0 0.0 %	5 7.4 %	36 52.9 %	27 39.7 %	68	4.32*	4.00	0.609

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5, importance rating -1 never important, 2- often not- important, 3- important or not important, 4- sometimes important, and 5- very important.
Values in parenthesis equates to percentage response.

Table 7.44 Rank Rating Results for Planning Variables (PLv).

Variable Code	Rank Scale (1-6)						Total	Mean	Median	Standard Deviation
	1 [0.16] (%)	2 [0.33] (%)	3 [0.5] (%)	4 [0.66] (%)	5 [0.83] (%)	6 [1.0] (%)				
PLv1	2 2.9 %	6 8.8 %	0 0.0 %	11 16.2 %	22 32.4 %	27 39.7 %	68	2.15	2.00*	1.352
PLv2	1 1.5 %	5 7.4 %	16 23.5 %	8 11.8 %	23 33.8 %	15 22.1 %	68	2.65*	2.00	1.336
PLv3	0 0.0 %	8 11.8 %	16 23.5 %	11 16.2 %	17 25.0 %	16 23.5 %	68	2.75*	3.00	1.365
PLv4	10 14.7 %	24 35.3 %	5 7.4 %	20 29.4 %	2 2.9 %	7 10.3 %	68	3.99*	4.50	1.521
PLv5	10 14.7 %	19 27.9 %	13 19.1 %	14 20.6 %	12 17.6 %	0 0.0 %	68	4.01*	4.00	1.344
PLv6	28 41.2 %	17 25.0 %	15 22.1 %	7 10.3 %	0 0.0 %	1 1.5 %	68	4.93*	5.00	1.137

Note: * variables as coded from the CEPM survey questionnaires.
1-2-3-4-5- 6, Ranking rate -6 most important, not importance.
[ ]equivalent rank values; Values in parenthesis equates to percentage response.

Table 7.45 Skewness Measure (*sk*) Values for Importance Rating of Planning Variables.

Planning variables (Importance Rating)	*sk* Value	Remarks
PL*v*1	- 0.820	Slightly negatively skewed distribution (use mean values)
PL*v*2	- 0.890	Slightly negatively skewed distribution (use mean values)
PL*v*3	- 0.808	Slightly negatively skewed distribution (use mean values)
PL*v*4	- 0.767	Slightly negatively skewed distribution (use mean values)
PL*v*5	- 1.298	Negatively skewed distribution: (use median values) require transformation on the data.
PL*v*6	- 0.303	Slightly negatively skewed distribution (use mean values)

Table 7.46 Skewness Measure (*sk*) Values for Rank Rating of Planning Variables.

Planning variables (Importance Rating)	*sk* Value	Remarks
rPL*v*1	+ 1.366	Positively skewed distribution: (use median values) require transformation on the data.
rPL*v*2	+ 0.449	Slightly positively skewed distribution (use mean values)
rPL*v*3	+ 0.179	Slightly positively skewed distribution (use mean values)
rPL*v*4	- 0.499	Slightly negatively skewed distribution (use mean values)
rPL*v*5	- 0.104	Slightly negatively skewed distribution (use mean values)
rPL*v*6	- 0.919	Slightly negatively skewed distribution (use mean values)

Table 7.47 Importance and Rank Rating Results for Planning Variables.

Planning variables	Importance rating (IR)		Rank Rating (RR)	
PLv1	Sometimes important	0.8470 %	Rank [2]	0.4882 %
PLv2	Sometimes important	0.8705 %	Rank [2]	0.4352 %
PLv3	Sometimes important	0.9058 %	Rank [2]	0.4250 %
PLv4	Sometimes important	0.8323 %	Rank [3]	0.3014 %
PLv5	Sometimes important	0.8529 %	Rank [4]	0.2985 %
PLv6	Sometimes important	0.8647 %	Rank [4]	0.2073 %

Table 7.48 Planning Variables: Correlation between *IR* and *RR*.

Planning variables	Pearson Correlation Sig. at 0.01 level (2-tailed)
PLv1: rPLv1	0.242
PLv2: rPLv2	0.338
PLv3: rPLv3	0.013
PLv4: rPLv4	0.807
PLv5: rPLv5	0.657
PLv6: rPLv6	0.528

7.10 SUMMARY

This chapter sought to elicit professional opinions of CEPMs. A total of 68 questionnaires were returned from CEPMs that were posted and this indicated a 13.6 percent return rate; these completed questionnaires were analysed to obtain statistical inference of data. Summary statistics of seven generic factors revealed that education and training is the most important factor when considering the selection of CEPM. Planning (PL*v*), project quality control (QC*v*), motivation (B*v*) and management (M*v*) factors were rated sometimes important whilst the work situational (WS*v*) factor was rated with neither important or not important.

Consequentially, after analysing theses generic factors using summary statistical analysis, the following observations were highlighted:

i. Education and Training (ET*v*) variables: practical building knowledge and experience (ET*v*3), specific vocational background (ET*v*2), qualification (ET*v*1)and specific training in project management (ET*v*4) were rated sometimes important and practical building knowledge and experience (ET*v*3) was ranked 2.

ii. Planning variables (PL*v*): scheduling key project activities at completion of the project design phase (PL*v*1), recognition of the interdependence of the project activities (PL*v*2), identifying any critical items to the project's success early (PL*v*3).

iii. Project quality control variables (QC*v*): ensuring project quality in order to achieve customer satisfaction (QC*v*1) and employing quality assurance processes, tools and metrics (QC*v*5) were ranked and rated sometimes important.

iv. Management variables (M*v*): authority to deal with people or problems as they occur (M*v*2) was rated and ranked sometimes important.

v. Motivation variables (B*v*): job promotion (B*v*6) and additional bonus payment for output of quality work (B*v*3) were rated and ranked the highest sometimes important.

vi. Personal variables (P*v*): reliability (P*v*5) and intelligence (P*v*6) were rated and ranked sometimes important.

vii. Work situational variables (WS*v*): an ability to ensure the health, safety and welfare of others on site (WS*v*5) was rated and ranked sometimes important.

Having observed and determined the trends of the data results, the next chapter discusses and derives the weighting indices (*WI*) of variables.

CHAPTER _8_
The Profile of a Civil Engineering Project Manager's (CEPM) Aptitude

8.0 INTRODUCTION

Having analysed data in the previous chapter, results obtained are now used to derive the weighting indices (*WI*) of variables within each of the generic factor; where *WI* is expressed as $WI = 0.5IR + 0.5RR$ (refer back to chapter 6). Specifically, *WI* calculations for each of the seven generic factors (and its variables) are presented; namely: i) Education and Training factor (ET*v*); ii) Planning factor (PL*v*); iii) Project quality control factor (QC*v*); iv) Motivation factor (B*v*); v) Management factor (M*v*); vi) Personal factor (P*v*); and vii) Work situational factor (WS*v*). Theses corresponding *WI* values were calculated for their respective percentage weight relative to the overall weight. A general summary of *WI* and importance rating of variables are also presented to provide the overall findings of the research survey undertaken.

8.1 THE WEIGHTING INDICES

Table 8.1 presents the values derived for the seven generic factors. The findings revealed that the education and training factor (ET*v*) had the highest weighting of the seven factors with 18.59 percent. This was followed by the planning factor (17.40 percent); quality control (14.57 percent); motivational factor (14.24 percent); management factor (13.95 percent); personal factor (12.97 percent); and work situational factor (8.25 percent).

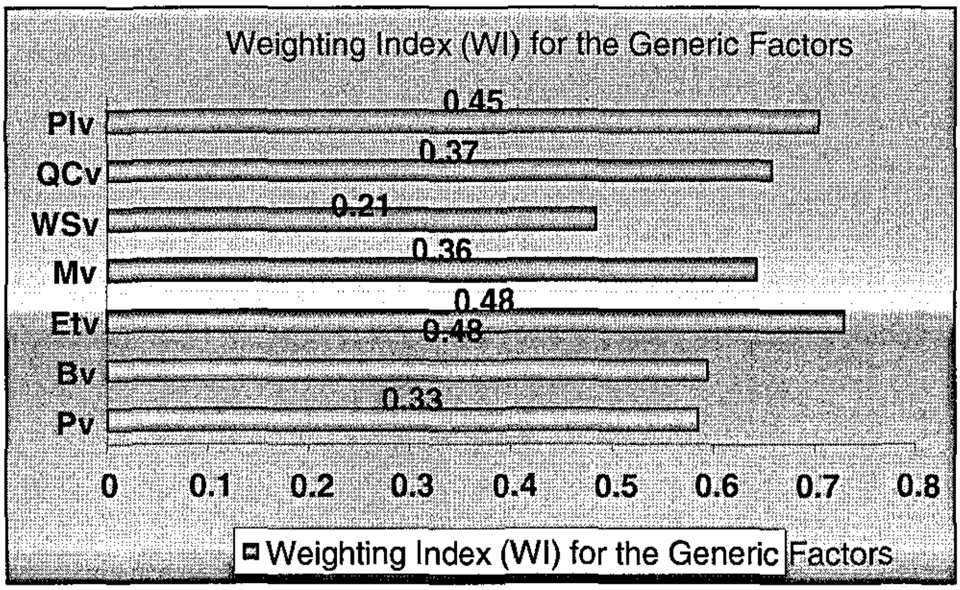
These percentage weightings of the generic factors were then utilised to calculate the relative percentage weighting of variables within each factor. The derived weighting indices of the factors and the percentage weight of these factors are presented in Table 8.1.

Table 8.1 Weighting Index (*WI*) of Generic Factors.

Factor	*WI*	% Weighting
ET	0.48	18.59
PL	0.45	17.40
QC	0.37	14.57
B	0.37	14.24
M	0.36	13.95
P	0.33	12.97
WS	0.21	08.25
Total	**2.5987**	**100.00**

The *WI* values for the variables were translated into an importance rating which could be readily interpreted. The scale were provided in the following range: very important (0.85 to 1.0); important (0.7 to 0.84); some important (0.55 to 0.69); often not important (0.35 to 0.54); and never important (0.1 to 0.34). Having categorised factors responses, a decision was made to exclude *WI* ratings that equate to often not important and never important from any future analysis. The exclusion formed part of a rational and systematic approach to reduce the number of variables considered in the final modelling process. For this reason, this method of elimination strengthens and simplifies the study by concentrating upon the statistically strong and valid variables. Figure 8.1 shows the weighting index (*WI*) for the generic factors.

Figure 8.1 Weighting Index (*WI*) for the Generic Factors.



8.2 EDUCATION AND TRAINING VARIABLES

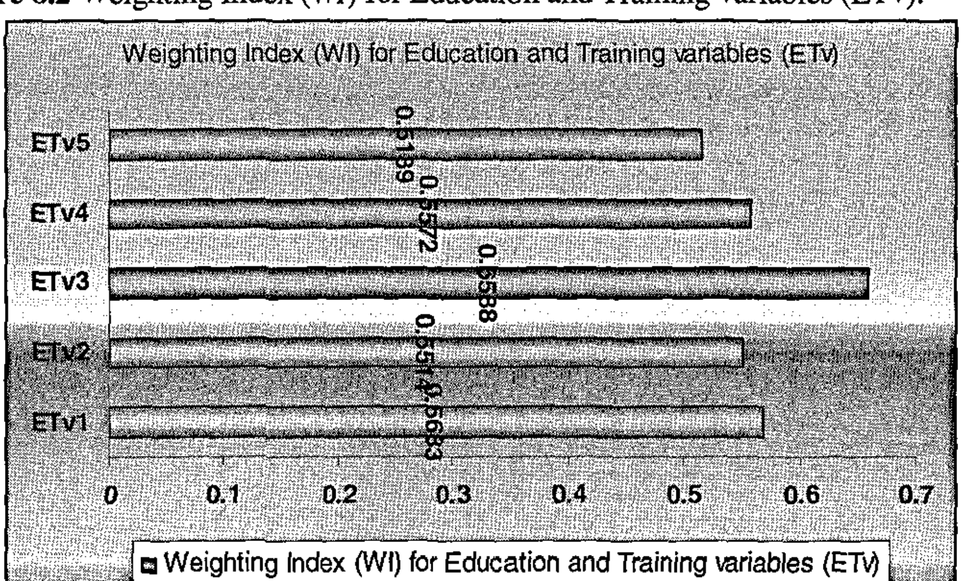
In Table 8.2, findings revealed that only one of the five ET*v* variables was rated often not important which obtained a *WI* value of 0.51. This variable was ET*v*5 (continual professional training certificates and/or attendance at relevant events). This variable shall be excluded for future classification analysis. All other variables were rated some importance with *WI* values of 0.55 to 0.65. These are ET*v*1 (qualification); ET*v*2 (specific vocational background); ET*v*3 (practical building knowledge and experience); and ET*v*4 (specific training in project management).

Table 8.2 Weighting Index (*WI*) of Education and Training Variables (ET*v*).

Education and Training variables	*WI* value	Percentage Weight (%)	Importance Rating
ET*v*1	0.56	19.94	Some importance
ET*v*2	0.55	19.35	Some importance
ET*v*3	0.65	23.11	Some importance
ET*v*4	0.55	19.55	Some importance
ET*v*5	0.51	18.03	Often not important
Total	**2.8496**	**100.00**	

Figure 8.2 shows the weighting index (*WI*) for the Education and Training Variables (ET*v*)

Figure 8.2 Weighting Index (*WI*) for Education and Training variables (ETv).



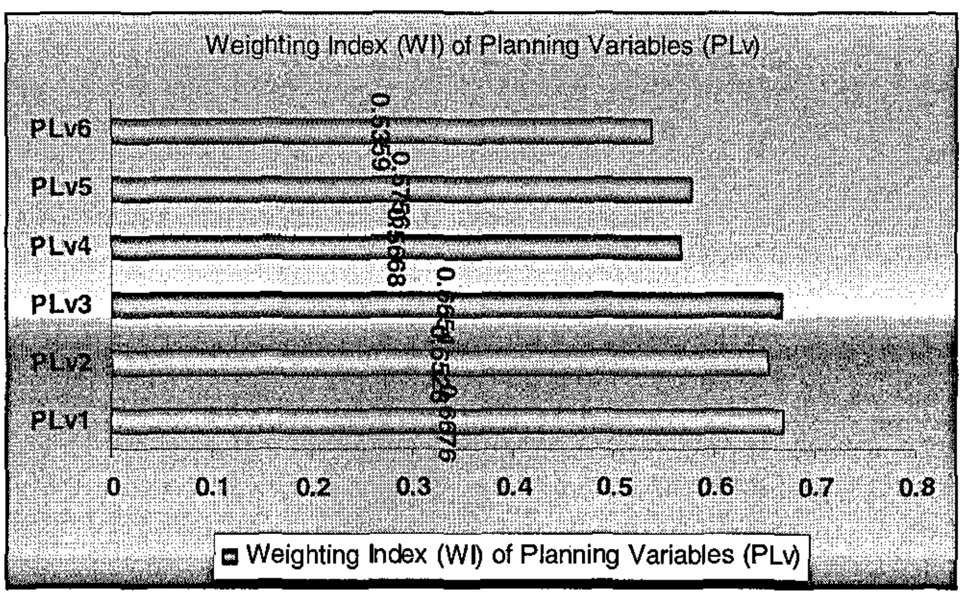
8.3 PLANNING VARIABLES (PL*V*)

In Table 8.3, illustrates that five of six planning variables have *WI* values more than 0.55. The highest value is PL*v*1 (scheduling key project activities at completion of the project design phase) with 0.66 *WI* and a percentage weight of 18.22. PL*v*3 (identifying any critical items to the project's success early) has 0.66 *WI*, PL*v*2 (recognition of the interdependence of the project activities) has 0.65 *WI*, PL*v*5 (quality materials selection and storage of these on site) has 0.57 *WI* and PL*v*4 (seeking the best cost estimates for works undertaken) has 0.56 *WI*. The PL*v*6 (selection of appropriate plant and equipment) obtained a *WI* Of 0.53 which suggested a weak rating (often not important). For this reason, PL*v*6 shall be excluded from any future classification analysis.

Table 8.3 Weighting Index (*WI*) of Planning Variables (PL*v*).

Planning variables	*WI* value	Percentage Weight (%)	Importance Rating
PL*v*1	0.66	18.22	Some importance
PL*v*2	0.65	17.81	Some importance
PL*v*3	0.66	18.15	Some importance
PL*v*4	0.56	15.46	Some importance
PL*v*5	0.57	15.70	Some importance
PL*v*6	0.53	14.62	Often not important
Total	**3.6641**	**100.00**	

Figure 8.3 Weighting Index (*WI*) for Planning variables (ETv).



8.4 QUALITY CONTROL VARIABLES (QCV)

In Table 8.4, one variable QC*v*1 (ensuring project quality in order to achieve customer satisfaction) of the eight variables has *WI* value 0.70 and rated important. All other variables were rated some important with *WI* values of 0.66, 0.64, 0.63, 0.63, 0.62, 0.58 and 0.58; these are QC*v*5 (employing quality assurance processes, tools and metrics), QC*v*3 (creating a quality management plan to deliver promised value), QC*v*6 (maintaining project quality control, correcting deviations and avoiding defect reoccurrence), QC*v*4 (translating expectations into specific deliverables to meet customer requirements), QC*v*7 (including all project partners in the monitoring of quality process) and QC*v*8 (planning general alternatives for any contingency that may arise) respectively.

Table 8.4 Weighting Index (*WI*) of Quality Control Variables (QC*v*).

Quality Control variables	*WI* value	Percentage Weight (%)	Importance Rating
QC*v*1	0.70	13.84	Important
QC*v*2	0.58	11.43	Some importance
QC*v*3	0.64	12.76	Some importance
QC*v*4	0.63	12.50	Some importance
QC*v*5	0.66	13.13	Some importance
QC*v*6	0.63	12.59	Some importance
QC*v*7	0.62	12.24	Some importance
QC*v*8	0.58	11.47	Some importance
Total	**5.0727**	**100.00**	

Within this factor no variables that need to be excluded for future classification analysis.

8.5 MANAGEMENT VARIABLES (MV)

Management variables (Table 8.5) all obtained *WI* values of more than 0.55. These results show that that the CEPM must have good management shills. The finding suggests that all of these management variables are strong variables that would qualify for future classification analysis. The variable with the highest value of *WI* is M*v*2 (authority to deal with people or problems as they occur) with 1.0 and rated very important. M*v*4 (leadership qualities to encourage personnel to be effective and efficient), M*v*1 (the level of responsibility and autonomy given, to act as appropriate when action is required), M*v*5 (an ability to control the construction process) and M*v*3 (accountability for both projects successes and failure) were all rated very important with *WI* value 0.96, 0.95, 0.92 and 0.88 respectively. All other variables were rated some importance.

Table 8.5 Weighting Index (*WI*) of Management Variables (M*v*).

Quality Control variables	*WI* value	Percentage Weight (%)	Importance Rating
M*v*1	0.95	09.06	Very important
M*v*2	1.00	09.50	Very important
M*v*3	0.88	08.37	Very important
M*v*4	0.96	09.12	Very important
M*v*5	0.92	08.74	Very important
M*v*6	0.82	07.80	Important
M*v*7	0.80	07.64	Important
M*v*8	0.77	07.37	Important
M*v*9	0.70	06.70	Important
M*v*10	0.72	06.89	Important
M*v*11	0.64	06.13	Some importance
M*v*12	0.70	06.68	Important
M*v*13	0.62	05.95	Some importance
Total	**10.5039**	**100.00**	

8.6 MOTIVATION VARIABLES (B*V*)

In Table 8.6, illustrates that four variables out of six were rated some importance with *WI* values 0.65, 0.63, 0.61 and 0.57. These variable; B*v*6 (job promotion opportunities), B*v*1 (basic salary), B*v*3 (additional bonus payment for output of quality work) and B*v*4 (team-based bonus for timely project completion) respectively. On the other hand, there are two variables B*v*5 (additional payment for completing the project on time or early) and B*v*2 (non financial fringe benefits and incentives such as education opportunities) that were rated often not importance with *WI* 0.54 and 0.49 respectively. These two, often not important B*v* variables shall be excluded from future classification analysis.

Table 8.6 Weighting Index (*WI*) of Motivation Variables (B*v*).

Motivation variables	*WI* value	Percentage Weight (%)	Importance Rating
B*v*1	0.63	17.96	Some importance
B*v*2	0.49	14.07	Often not important
B*v*3	0.61	17.38	Some importance
B*v*4	0.57	16.31	Some importance
B*v*5	0.54	15.50	Often not important
B*v*6	0.65	18.76	Some importance
Total	**3.5148**	**100.00**	

8.7 PERSONAL VARIABLES (PV)

In Table 8.7, findings revealed that six of the ten P*v* variables were rated importance and these obtained a *WI* value of 0.80, 0.80, 0.80, 0.72, 0.72 and 0.70. These variables are P*v*6 (intelligence), P*v*5 (reliability), P*v*7 (dependability), P*v*9 (flexibility), P*v*10 (cooperative) and P*v*4 (personal disposition) respectively. One variable Pv8 (personality agreeableness and openness to new experiences) was rated some importance with *WI* 0.69. The other three variables were rated often not important with *WI* values of 0.54, 0.42 and 0.38. and these variables were P*v*1 (age), P*v*2 (gender) and P*v*3 (marital status) respectively. Because these three variables are not considered important, they will be excluded from any future classification analysis.

Table 8.7 Weighting Index (*WI*) of Personal Variables (P*v*).

Personal variables	*WI* value	Percentage Weight (%)	Importance Rating
P*v*1	0.54	08.16	Often not important
P*v*2	0.42	06.47	Often not important
P*v*3	0.38	05.85	Often not important
P*v*4	0.70	10.62	Important
P*v*5	0.80	12.18	Important
P*v*6	0.80	12.20	Important
P*v*7	0.80	12.06	Important
P*v*8	0.69	10.51	Some importance
P*v*9	0.72	10.96	Important
P*v*10	0.72	10.94	Important
Total	**6.6303**	**100.00**	

8.8 WORK SITUATIONAL VARIABLES (WS*V*)

Five of the seven variables within the work situational factor obtained *WI* values within the range of 0.60 to 0.69 (Table 8.8). These variables included WS*v*5 (an ability to ensure the health, safety and welfare of others on site) with a *WI* 0.69, WS*v*3 (project complexity) with a *WI* 0.65, WS*v*4 (working under the pressure of time particularly when contracts are behind schedule) with a *WI* 0.65, WS*v*7 (obtaining good co-worker support) with a *WI* 0.63 and WS*v*6 (site organisational abilities e.g. good clear site transport/pedestrian routes, storage areas etc) with a *WI* 0.60. Two of the seven work situational variables fell below the neutral rating (less than 0.55) which meant that they shall be excluded from future classification modelling and analysis procedure. These variables were: WS*v*2 (site condition e.g. access and egress to work, available facilities and amenities etc.) with a *WI* 0.54 and WS*v*1 (working in extreme weather) with *WI* 0.46.

Table 8.8 Weighting Index (*WI*) of Work Situational Variables (WS*v*).

Work Situational variables	*WI* value	Percentage Weight (%)	Importance Rating
WS*v*1	0.46	10.99	Often not important
WS*v*2	0.54	12.72	Often not important
WS*v*3	0.65	15.39	Important
WS*v*4	0.65	15.39	Important
WS*v*5	0.69	16.32	Important
WS*v*6	0.60	14.29	Important
WS*v*7	0.63	14.86	Important
Total	**4.2591**	**100.00**	

8.9 GENERAL SUMMARY

All the weighting index values of the 55 variables were analysed and rated to the equivalent scale of importance. A summary of the findings of the weighting indices derived from the importance rating (*IR*) and ranking rating (*RR*) are presented in Table 8.9.

Table 8.9 Weighting Index (*WI*) of all variables.

No/Code	variable (description)	*WI*	Importance Rating
01- Mv2	Authority to deal with people or problem as they occur.	1.00	very important
02- Mv4	Leadership qualities.....	0.96	very important
03- Mv1	The level of responsibility	0.95	very important
04- Mv5	An ability to control the construction process.	0.92	very important
05- Mv3	Accountability for both projects successes and failures.	0.88	very important
06- Mv6	Time management	0.82	important
07- Pv6	Intelligence.	0.80	important
08- Pv5	Reliability.	0.80	important
09- Mv7	Problem solving capabilities.	0.80	important
10- Pv7	Dependability e.g. at times of urgency or emergency work.	0.80	important
11- Mv8	Dependability e.g. to execute a contract-efficiently and effectively.	0.77	important
12- Pv9	Flexibility.	0.72	important
13- Pv10	Cooperative.	0.72	important
14- Mv10	The ability to supervise personnel on site.	0.72	important
15- Mv9	An ability to create and administer clear management policies.	0.70	important
16- Pv4	Personal disposition.	0.70	important
17- Mv12	Influence in decision-making.	0.70	important
18- QCv1	Ensuring project quality.	0.70	important
19- Pv8	Personality agreeableness.	0.69	some importance
20- WSv5	An ability to ensure the health, safety and welfare of others on site.	0.69	some importance
21- PLv1	Scheduling key project activities at completion of the project phase.	0.66	some importance
22- QCv5	Employing quality assurance processes, tools and metrics.	0.66	some importance
23- PLv3	Identifying any critical items to the project's success early.	0.66	some importance
24- Bv6	Job promotion opportunities.	0.65	some importance
25- ETv3	Practical building knowledge and experience.	0.65	some importance
26- WSv3	Project complexity.	0.65	some importance
27- WSv4	Working under the pressure of time.	0.65	some importance
28- PLv2	Recognition of the interdependence of the project activities.	0.65	some importance
29- QCv3	Creating a quality management plan.	0.64	some importance
30- Mv11	Involvement in the production and/or management legal contracts.	0.64	some importance
31- QCv6	Maintaining project control.	0.63	some importance
32- QCv4	Translating expectations into specific deliverables to meet customer.	0.63	some importance
33- WSv7	Obtaining good co-worker support.	0.63	some importance
34- Bv1	Basic salary.	0.63	some importance
35- Mv13	Involvement in the preparation of project budgets.	0.62	some importance
36- QCv7	Including all project partners.	0.62	some importance
37- Bv3	Additional payment for output of quality work.	0.61	some importance
38- WSv6	Site organisational abilities.	0.60	some importance
39- QCv8	Planning general alternatives for any contingency that may arise.	0.58	some importance
40- QCv2	Establishing a quality-centred environment among project stakeholders.	0.58	some importance
41- PLv5	Quality materials selection and storage of these on site.	0.57	some importance
42- Bv4	Team-based bonus for timely project completion.	0.57	some importance
43- ETv1	Qualification (professional and further or higher education)	0.56	some importance
44- PLv4	Seeking the best cost estimates for works undertaken.	0.56	some importance
45- ETv4	Specific training in project management.	0.55	some importance
46- ETv2	Specific vocational background (civil engineer, architecture, etc.)	0.55	some importance
47- Bv5	Additional payment for completing the project on time or early.	0.54*	often not important
48- WSv2	Site conditions.	0.54*	often not important
49- Pv1	Age	0.54*	often not important
50- PLv6	Selection of appropriate plant and equipments.	0.53*	often not important
51- ETv5	Continual professional training certificates....etc.	0.51*	often not important
52- Bv2	Non financial fringe benefits ....etc.	0.49*	often not important
53- WSv1	Working in extreme weather.	0.46*	often not important
54- Pv2	Gender	0.42*	often not important
55- Pv3	Marital status.	0.38*	often not important

Scale of importance of variables:

1.0 – 0.85 = very important; 0.85 – 0.70 = important; 0.69 – 0.55 = some important; 0.54 – 0.35 = often not important;
2.0 0.34 – 0.1 = never important. * often not important and never important variables – to be excluded in future analysis.

Results reveal that overall, forty-six (46) variables were considered to be strong variables. These variables therefore formed the basis for the classification of CEPM aptitude.

On the other hand, weak variables are classified, with *WI* values of 0.55 or lower. There are nine (9) variables that were classified weak and these variables were excluded from future statistical modelling studies. The excluded variables were: B*v*5 (Additional payment for completing the project on time or early); WS*v*2 (Site conditions); P*v*1 (Age); PL*v*6 (Selection of appropriate plant and equipments); ET*v*5 (Continual professional training certificates and/or attendance at relevant events); B*v*2 (Non financial fringe benefits and incentives); WS*v*1 (Working in extreme weather); P*v*2 (Gender) and P*v*3 (Marital status), refer to Table 8.9.

Based on the derived *WI* values, another summary tabulation was produced to report upon the relative percentage weight of each of the variables (Table 8.10). The relative weighting index of each variable was then utilised to generate a random simulation procedure that was used as part of a statistical classification method to classifying the aptitude of the CEPM. this will be further discussed and elaborated upon further in Chapter 9.

The combined tabulation results for *WI* in Tables 8.9 and 8.10 provided the basic raw information for deriving a profile that could be used to determine the CEPM's capability.

Table 8.10 General Summary of Weighting Indices and Percentage Relative Weights.

Variable Number	Variable code	*WI*	Weighting index (Relative %)
01	M*v*2	1.00	2.73
02	M*v*4	0.96	2.62
03	M*v*1	0.95	2.60
04	M*v*5	0.92	2.51
05	M*v*3	0.88	2.41
06	M*v*6	0.82	2.24
07	P*v*6	0.80	2.19
08	P*v*5	0.80	2.19
09	M*v*7	0.80	2.19
10	P*v*7	0.80	2.19
11	M*v*8	0.77	2.10
12	P*v*9	0.72	1.97
13	P*v*10	0.72	1.97
14	M*v*10	0.72	1.97
15	M*v*9	0.70	1.91
16	P*v*4	0.70	1.91
17	M*v*12	0.70	1.91
18	QC*v*1	0.70	1.97
19	P*v*8	0.69	1.88
20	WS*v*5	0.69	1.88
21	PL*v*1	0.66	1.80
22	QC*v*5	0.66	1.80
23	PL*v*3	0.66	1.80
24	B*v*6	0.65	1.78
25	ET*v*3	0.65	1.78
26	WS*v*3	0.65	1.78
27	WS*v*4	0.65	1.78
28	PL*v*2	0.65	1.78
29	QC*v*3	0.64	1.75
30	M*v*11	0.64	1.75
31	QC*v*6	0.63	1.72
32	QC*v*4	0.63	1.72
33	WS*v*7	0.63	1.72
34	B*v*1	0.63	1.72
35	M*v*13	0.62	1.69
36	QC*v*7	0.62	1.69
37	B*v*3	0.61	1.67
38	WS*v*6	0.60	1.64
39	QC*v*8	0.58	1.58
40	QC*v*2	0.58	1.58
41	PL*v*5	0.57	1.56
42	B*v*4	0.57	1.56
43	ET*v*1	0.56	1.53
44	PL*v*4	0.56	1.53
45	ET*v*4	0.55	1.50
46	ET*v*2	0.55	1.50
47	B*v*5	0.54*	(1.47)
48	WS*v*2	0.54*	(1.47)
49	P*v*1	0.54*	(1.47)
50	PL*v*6	0.53*	(1.45)
51	ET*v*5	0.51*	(1.39)
52	B*v*2	0.49*	(1.34)
53	WS*v*1	0.46*	(1.25)
54	P*v*2	0.42*	(1.15)
55	P*v*3	0.38*	(1.04)
Total		36.4945	100.00

Table 8.10, presents 46 statistically strong variables considered. Five (5) variables were found to be very important. These are: M*v*2 (Authority to deal with people or problem as they occur), M*v*4 (Leadership qualities to encourage personnel to be effective and efficient), M*v*1(the level of responsibility and autonomy given, to act as

appropriate when action is required), M*v*5 (An ability to control the construction process) and (Accountability for both projects successes and failures). Thirteen (13) variables were considered important variables. These are: M*v*6 (time management), P*v*6 (intelligence), P*v*5 (reliability), M*v*7 (problem solving capabilities), P*v*7 (dependability e.g. at time of urgency or emergency work), M*v*8 (dependability e.g. to execute a contract-efficiently and effectively), P*v*9 (flexibility), P*v*10 (cooperative), M*v*11 (the ability to supervise personnel on site), M*v*9 (an ability to create and administer clear management policies), P*v*4 (personal disposition), M*v*12 (influence in decision-making) and QC*v*1 (ensuring project quality). The remaining variables were all considered to be some importance. These are: P*v*8 (Personality agreeableness), WS*v*5 (An ability to ensure the health, safety and welfare of others on site), PL*v*1 (Scheduling key project activities at completion of the project phase), QC*v*5 (Employing quality assurance processes, tools and metrics), PL*v*3 (Identifying any critical items to the project's success early), B*v*6 (Job promotion opportunities), ET*v*3 (Practical building knowledge and experience), WS*v*3 (Project complexity), WS*v*4 (Working under the pressure of time), PL*v*2 (Recognition of the interdependence of the project activities), QC*v*3 (Creating a quality management plan), M*v*11 (Involvement in the production and/or management legal contracts), QC*v*6 (Maintaining project control), QC*v*4 (Translating expectations into specific deliverables to meet customer satisfaction), WS*v*7 (Obtaining good co-worker support), B*v*1 (Basic salary), M*v*13 (Involvement in the preparation of project budgets), QC*v*7 (Including all project partners), B*v*3 (Additional payment for output of quality work), WS*v*6 (Site organisational abilities), QC*v*8 (Planning general alternatives for any contingency that may arise), QC*v*2 (Establishing a quality-centred environment among project stakeholders), PL*v*5 (Quality materials selection and storage of these on site), B*v*4 (Team-based bonus for timely project completion), ET*v*1 (Qualification (professional and further or higher education), PL*v*4 (Seeking the best cost estimates for works undertaken), ET*v*4 (Specific training in project management) and ET*v*2 (Specific vocational background (civil engineer, architecture, etc).

8.10 THE CONSTRUCTION MANAGER'S APTITUDE PROFILE SHEET

Having considered all variables within factors, a construction manager profile sheet was then developed to provide the company with a user friendly score sheet tool for collecting information and assessing a CEPM's aptitude. The score sheet used the percentage weight data for the 46 variables to benchmark CEPM aptitude. The percentage weight was rounded to the nearest whole number (simplified percentage weight) so that scales of measurement were easily quantified (Table 8.11). the summation of ratings provides a total score in which a boundary classification was established to determine poor, average and good construction manager (CEPM).

Table 8.11 Profile of Civil Engineering Project Manager's (CEPM) Aptitude.

Variable No	Code	Variable (description)	WI	% Weight
01-	Mv2	Authority to deal with people or problem as they occur.	1.00	3.11
02-	Mv4	Leadership qualities.....	0.96	2.99
03-	Mv1	The level of responsibility	0.95	2.96
04-	Mv5	An ability to control the construction process.	0.92	2.86
05-	Mv3	Accountability for both projects successes and failures.	0.88	2.74
06-	Mv6	Time management	0.82	2.55
07-	Pv6	Intelligence.	0.80	2.49
08-	Pv5	Reliability.	0.80	2.49
09-	Mv7	Problem solving capabilities.	0.80	2.49
10-	Pv7	Dependability e.g. at times of urgency or emergency work.	0.80	2.49
11-	Mv8	Dependability e.g. to execute a contract-efficiently and effectively.	0.77	2.40
12-	Pv9	Flexibility.	0.72	2.24
13-	Pv10	Cooperative.	0.72	2.24
14-	Mv10	The ability to supervise personnel on site.	0.72	2.24
15-	Mv9	An ability to create and administer clear management policies.	0.70	2.18
16-	Pv4	Personal disposition.	0.70	2.18
17-	Mv12	Influence in decision-making.	0.70	2.18
18-	QCv1	Ensuring project quality.	0.70	2.18
19-	Pv8	Personality agreeableness.	0.69	2.15
20-	WSv5	An ability to ensure the health, safety and welfare of others on site.	0.69	2.15
21-	PLv1	Scheduling key project activities at completion of the project phase.	0.66	2.05
22-	QCv5	Employing quality assurance processes, tools and metrics.	0.66	2.05
23-	PLv3	Identifying any critical items to the project's success early.	0.66	2.05
24-	Bv6	Job promotion opportunities.	0.65	2.02
25-	ETv3	Practical building knowledge and experience.	0.65	2.02
26-	WSv3	Project complexity.	0.65	2.02
27-	WSv4	Working under the pressure of time.	0.65	2.02
28-	PLv2	Recognition of the interdependence of the project activities.	0.65	2.02
29-	QCv3	Creating a quality management plan.	0.64	1.99
30-	Mv11	Involvement in the production and/or management legal contracts.	0.64	1.99
31-	QCv6	Maintaining project control.	0.63	1.96
32-	QCv4	Translating expectations into specific deliverables to meet customer.	0.63	1.96
33-	WSv7	Obtaining good co-worker support.	0.63	1.96
34-	Bv1	Basic salary.	0.63	1.96
35-	Mv13	Involvement in the preparation of project budgets.	0.62	1.93
36-	QCv7	Including all project partners.	0.62	1.93
37-	Bv3	Additional payment for output of quality work.	0.61	1.90
38-	WSv6	Site organisational abilities.	0.60	1.87
39-	QCv8	Planning general alternatives for any contingency that may arise.	0.58	1.80
40-	QCv2	Establishing a quality-centred environment among project stakeholders.	0.58	1.80
41-	PLv5	Quality materials selection and storage of these on site.	0.57	1.77
42-	Bv4	Team-based bonus for timely project completion.	0.57	1.77
43-	ETv1	Qualification (professional and further or higher education)	0.56	1.74
44-	PLv4	Seeking the best cost estimates for works undertaken.	0.56	1.74
45-	ETv4	Specific training in project management.	0.55	1.71
46-	ETv2	Specific vocational background (civil engineer, architecture, etc.)	0.55	1.71
Total			**32.05**	**100.00**

Appendix C presents the CEPM profile sheet. Determination of aptitude (using the total score) was obtained by delineating and defining the cut-off points (boundaries) between good to average and average to poor CEPM. Respondents indicated that the classification cut-off points were as follows (refer back to Figure 6.3): Group 1- poor CEPM (19.7 percent); Group 2- average CEPM (60.6 percent); and Group 3- good CEPM (19.7 percent). Equipped with the knowledge of cut-off points, it can be established that using the profile of 46 variables, the good CEPM can be determined when total scores are between 80.3 percent and 100 percent. Average CEPMs can be determined when total scores are between 19.7 percent and 60.6 percent. Poor CEPM can be determined when the total scores are less than 19.7 percent.

8.11 SUMMARY

In this chapter the way of calculation the weight indices technique were carry out in order to find the weakest variable that will be excluded to the main analysis. The 55 variables studied, 46 proved to be significantly important and were considered as key variables in the profile development. A benchmark using a scale of measurements derived from these 46 statistically strong variables was then established and presented in Table 8.11. This benchmark was developed to derive a profile of CEPM's aptitude.

Finally, by having developed the profile of CEPM's aptitude based on 46 statistically strong variables, the study seeks to derive the least number and most appropriate variables that can be considered for classifying the aptitude of CEPM. Such a methodology requires a statistical classification procedure of which *WI* values are randomly generated and integrated to develop into mathematical classification models.

CHAPTER _9_

Classifying the Aptitude of the CEPM Using the MDA Classification Technique

9.0 INTRODUCTION

In chapter 8, the weighting indices for each of the 55 identified variables were derived. These weighting indices were summarised and ranked accordingly and 46 key variables were translated into a profile of CEPM's aptitude.

Pearson's product moment correlation analysis (conducted in chapter 7) revealed that a number of independent variables were significantly correlated with the dependent variables. However, while the level of association was acceptable, it was evident that there was dispersion in the data and that highly correlated variables could not be used in isolation to model the dependent variable. Hence, there is the need to embrace multivariate modelling techniques. Having derived the percentage weight values of the variables, random numbers were generated and integrated into these values to develop classification models using MDA.

This chapter presents the MDA classification models that utilise *WI* values generated in chapter 8. These models were constructed to categorise CEPM attributes (variables) into distinct groups of good, average and poor CEPM. Individual MDA modelling for each factor was able to derive the variables necessary to classify group category of CEPM aptitude. These variables were then combined with the obtained profile variables in chapter 8. Using a combination of both results, a general MDA model was derived to represent an overall model of predicting a CEPM's potential aptitude.

9.1 MDA MODEL DEVELOPMENT

This research sought to obtain the least (more significant) number of variables required to classify the CEPM's aptitude. Using this objective, the work would deliver the optimum model solution to industry practitioners (as measured in terms of computational time and accuracy). The MDA classification technique met these requirements in determining the least number of variables that can provide both efficiency and reliability to the classification models.

For the model development process, a three-stage iterative procedure was employed. This consisted of i) software selection; ii) data coding; and iii) analysis procedure.

9.1.1 Software Selection

A wide variety of statistical analysis software packages are available to researchers and these include: Microsoft Excel; Minitab; Neural Networks; and Statistics for the Social Scientists (SPSS) etc. After much deliberation and assessment, the decision was taken to use SPSS version 14.0; the underlying rationale for this decision being that SPSS is a user friendly environment provides in-depth supporting technical information; and offers files transfer from MS Excel into SPSS directly.

9.1.2 Data Coding

Prior to data analysis, a two stage data coding procedure was used. First, the sample was divided into a main test and development sample which constituted 75 percent of data collected and a hold-out validation sample which constituted the remaining 25 percent where the a hold-out validation sample were split randomly during creating the input file (setting-stage). Second, the dependent variable were classified as 3, 2 and 1 (for good, average and poor CEPMs respectively). Hence, a higher figure signifies a better CEPM.

9.1.3 Analysis Procedure

Stepwise variable selection means that one predictor variable is entered or removed from the model at each step of the variable selection process. While the stepwise procedure can work on forward or/and backward selection process, this research utilised both backward and forward direction of the stepwise for model development (Klecka, 1987). The stepwise procedure works in a manner that all of the variables are initially considered to be in and the weak or redundant variables are cast out at each step (ibid). This process goes on to remove weak or redundant variables until the desired number of variables can provide the most discriminating selection (Klecka, 1985). To ensure that industry takes up these research findings, it was important that any model created was as simple as possible, yet retained its accuracy.

At the same time, the stepwise procedure was not the only criteria used to exclude variables from the model. In this research (*vibe* chapter 8), statistical results of importance rating and corresponding *WI* were tabulated. Based on these findings (in Table 8.11), it was decided that variables with rating often not important and never important should be excluded in order to simplify the classification model procedure. Such variables were considered weak and were eliminated in order to avoid distraction in future analysis. In total, nine variables were rated weak and these are listed in Table 9.1.

Table 9.1 List of Excluded Variables.

Factor		Variable Code	Variable (description)
Personal:			
	(1)	Pv1	Age
	(2)	Pv2	Gender
	(3)	Pv3	Marital Status
Motivation:			
	(1)	Bv2	Non financial fringes benefits,..etc
	(2)	Bv5	Additional payment for completing the project on time or early.
Education & Training:			
	(1)	ETv5	Continual professional training certificates....etc.
Work Situational:			
	(1)	WSv2	Site conditions.
	(2)	WSv1	Working in extreme weather.
Planning			
	(1)	PLv6	Selection of appropriate plant and equipments
Total:			**9 Variables**

Having eliminated the weak variables, the percentage weight of each of the remaining variables was recalculated. Corresponding values for the relative weight index were adjusted to conform to the reduced number of variables (46 variables altogether, instead of 55). The corrected values of the relative weighting index of each variable are presented in Table 9.2. These obtained values are again generated randomly to create data for the classification modelling and analysis.

Table 9.2 The Relative Weighting Index (*WI*) of 46 Variables of the Study.

Variable Code	Relative Percentage Weight (%)	Variable Code	Relative Percentage Weight (%)
P*v*4	0.70	M*v*9	0.70
P*v*5	0.80	M*v*10	0.72
P*v*6	0.80	M*v*11	0.64
P*v*7	0.80	M*v*12	0.70
P*v*8	0.69	M*v*13	0.62
P*v*9	0.72	WS*v*3	0.65
P*v*10	0.72	WS*v*4	0.65
B*v*1	0.63	WS*v*5	0.69
B*v*3	0.61	WS*v*6	0.60
B*v*4	0.57	WS*v*7	0.63
B*v*6	0.65	QC*v*1	0.70
ET*v*1	0.56	QC*v*2	0.58
ET*v*2	0.55	QC*v*3	0.64
ET*v*3	0.65	QC*v*4	0.63
ET*v*4	0.55	QC*v*5	0.66
M*v*1	0.95	QC*v*6	0.63
M*v*2	1.00	QC*v*7	0.62
M*v*3	0.88	QC*v*8	0.58
M*v*4	0.96	PL*v*1	0.66
M*v*5	0.92	PL*v*2	0.65
M*v*6	0.82	PL*v*3	0.66
M*v*7	0.80	PL*v*4	0.56
M*v*8	0.77	PL*v*5	0.57

The final stage of the analysis procedure involved an analysis of variables within each of seven factors as a priori to an analysis of all variables within all factors.

This approach is based upon the knowledge that the use of a stepwise procedure will exclude some variables from the model even though these may be important predictor variables (e.g. when two variables are auto-correlated with the dependent variable). Statisticians recommend that one of the independent variables is excluded from any further analyses. Clearly, it would be erroneous to have two variables providing the same information as this would over complicate the equation developed. However, exclusion of variables can also have negative results. That is, variables within a factor (factor a) may not be entered into the model when variables within factors b, c or d are considered. Therefore, by considering each factor (and variables within these) in turn a more intricate understanding of the relationship between all independent factors and the dependent variables can be acquired.

9.2 PERSONAL FACTOR: MDA CLASSIFICATION OF PERSONAL VARIABLES

After removing the variables listed in Table 9.1, the personal factor consisted of seven remaining variables. Table 9.3 showed the *WI* and percentage weight of each variable of these seven variables; variables with a hyphen denote those that were excluded from future analysis (refer to column on corrected percentage weight). Based upon the corrected percentage weight values, the relative weighting indices were also calculated. The relative weighting index of variables describes the percentage weight of the variable it terms of the overall weight to the entire study.

Table 9.3 The Weighting Indices (*WI*) Values of Personal Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
Pv1	(0.54)	(08.16)	-	-
Pv2	(0.42)	(06.47)	-	-
Pv3	(0.38)	(05.85)	-	-
Pv4	0.70	10.62	13.23	1.99
Pv5	0.80	12.18	15.12	2.28
Pv6	0.80	12.20	15.12	2.28
Pv7	0.80	12.06	15.12	2.28
Pv8	0.69	10.51	13.04	1.96
Pv9	0.72	10.96	13.61	2.05
Pv10	0.72	10.94	13.61	2.05
Total	**6.6303 (5.290)**	**100.00**	**100.00**	**14.89**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model and is presented in Table 9.4. This model consist of two personal variables. These variables included Pv4 (personal disposition) and Pv10 (cooperative e.g. helpful and able to work with others). This model has two corresponding function (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.4 MDA Model Development for Personal Variables Using Stepwise Method.

MDA Model No	Function No	Pv4	Pv10	Constant	Accuracy (%)
I (2-var.)					
	F1	**0.751**	**0.969**	**-1.047**	**68.60**
	F2	-0.799	1.024	-7.385	-

From the F1 model in Table 9.4, the following equation can be formulated as follows:

Model Developed : (2 - variables)

Function 1: $0.751\,Pv4 + 0.969Pv10 - 1.047$

The values of statistical measurement of the model was also derived and presented in Table 9.5. It was observed that F1 model provided high Eigenvalue (0.599) that showed the characteristic of a good function when compared to the low values of F2 (0.007). The Wilks lambda for F1 model also showed near zero values (0.621) which means that group centroids were distinctly separated between groups. The transformation of Wilks lambda determines significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model could be rejected. The canonical correlation of F1 model also showed a high range (0.612) which means that about 61.2 percent of the total variance were being accounted for by this F1 model.

Table 9.5 The MD Statistical Results of the Model (Personal Variables).

MDA Model No	Function No	Eigenvalue	Wilks Lambda				Canonical correlation
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.599	0.621	22.651	4	0.000	0.612
	F2	0.007	0.993	0.345	1	0.557	0.085

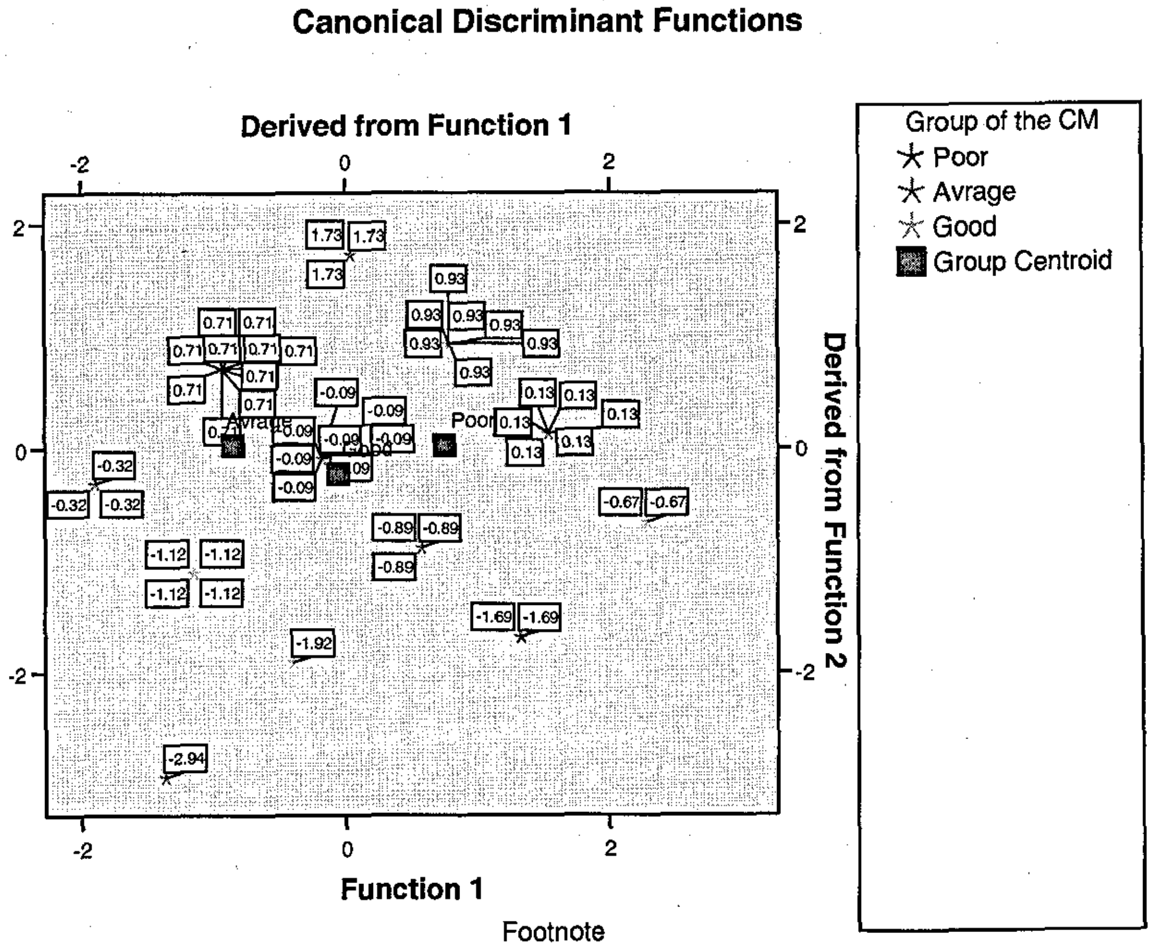
Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.6.

Table 9.6 Model Performance Evaluation (Personal Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	**68.6**	**75.0**	**81.0**	**66.70**

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 68.6 percent. Poor CEPM's were classified at 81.0 percent accuracy. The average CEPM's were classified at 81.0 percent accuracy and good CEPM's classified at 66.7 percent accuracy. A diagrammatic representation of the classification results of the model are provided in Figure 9.1.

Figure 9.1 Classification Results of the Personal Variables (Two Variables- Group Centroids).



The two personal variables that are acceptably accurate in classifying CEPM's aptitude can be formulated to form the equation:

$$CEPM's_{(APv)} = a\,Pv4 + bPv10 + K$$

Where CEPM's $_{(APv)}$ is the civil engineering project manager aptitude in terms of the Personal Factor, a and b are the coefficient of the variable, Pv4 is personal disposition and Pv10 is cooperative e.g. helpful and able to work with others.

9.3 MOTIVATION FACTOR: MDA CLASSIFICATION OF MOTIVATION VARIABLES

The weighting indices, percentage weights and relative weighting indices of the six (6) variables under the motivation factor are presented in Table 9.7. A correction for percentage weight values were calculated because statistical results showed that two variables were excluded having been observed as weak variables. These variables were Bv2 (non financial fringe benefits and incentives such as education opportunities) and Bv5 (additional payment for completing the project on time or early). The values derived for relative weighting indices were utilised to develop the classification model for the variables of the motivation factor.

Table 9.7 The Weighting Indices (*WI*) Values of Motivation Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
B*v*1	0.63	17.96	25.35	07.21
B*v*2	(0.49)	(14.07)	-	-
B*v*3	0.61	17.38	24.54	06.98
B*v*4	0.57	16.31	22.93	06.52
B*v*5	(0.54)	(15.50)	-	-
B*v*6	0.65	18.76	26.15	07.43
Total	**3.5148 (2.4848)**	**100.00**	**100.00**	**28.14**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model and is presented in Table 9.8. This model consisted of two variables. These variables included B*v*4 (team-based bonus for timely project completion) and B*v*6 (job promotion opportunities). This model had two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.8 MDA Model Development for Motivation Variables Using Stepwise Method.

MDA Model No	Function No	Bv4	Bv6	Constant	Accuracy (%)
I (2-var.)					
	F1	**1.683**	**0.587**	**-9.261**	**64.70**
	F2	-0.826	1.361	-2.567	-

From the F1 model in Table 9.8, the following equation was formulated as follows:

Model Developed : (2- variables)

$$\textit{Function1:} \quad 1.683Bv4 + 0.587Bv6 - 9.261$$

The values of statistical measurement of the model was also derived and presented in Table 9.9. It was observed that F1 model provided high Eigenvalue (0.697) that showed the characteristic of a good function when compared to the low values of F2 (0.119). The Wilks lambda for F1 model also showed near zero values (0.527) which means that group centroids were distinctly separated between groups. The transformation of Wilks lambda determents significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model could be rejected. The canonical correlation of F1 model also showed a high range (0.893) which means that about 64.1 percent of the total variance was accounted for by this F1 model.

Table 9.9 The MD Statistical Results of the Model (Motivation Variables).

MDA Model No	Function No	Eigenvalue	Wilks Lambda				Canonical correlation
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.697	0.527	30.468	4	0.000	0.641
	F2	0.119	0.893	5.353	1	0.021	0.326

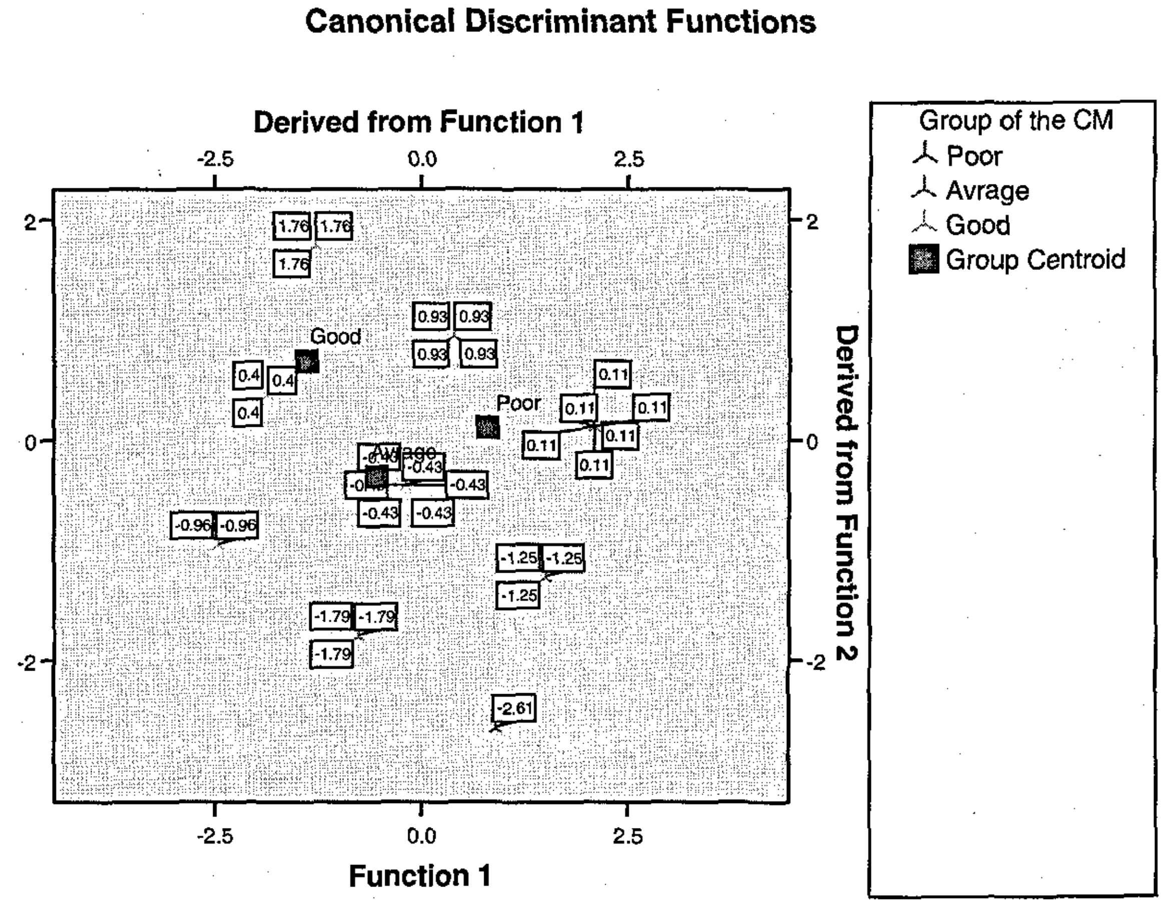
Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.10.

Table 9.10 Model Performance Evaluation (Motivation Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (3-var.)	64.7	83.3	71.4	50.0

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 64.7 percent. Poor CEPM's were classified at 83.3 percent accuracy. The average CEPM's were classified at 71.4 percent accuracy and good CEPM's classified at 50.0 percent accuracy. Next, a diagrammatic representation of the classification results of the model is presented in Figure 9.2.

Figure 9.2 Classification Results of the Motivation Variables (Two Variables-Group Centroids)



This model provided, at most, two personal variables that are acceptably accurate in classifying the CEPM's aptitude. Such variables can be formulated to form the equation:

$$CEPM's_{(ABv)} = a\,Bv4 + bBv6 + K$$

Where CEPM's $_{(ABv)}$ is the civil engineering project manager's aptitude in terms of the Motivation Factor, a and b are the coefficients of the variable, Bv4 is team-based bonus for timely project completion and Bv6 is job promotion opportunities and K is the constant.

9.4 EDUCATION AND TRAINING FACTOR: MDA CLASSIFICATION OF EDUCATION AND TRAINING VARIABLES

The *WI* of each of the education and training (ET*v*) variables was derived in Chapter 8. The *WI* values further derived the percentage weight and the relative weighting index of each variable. Table 9.11 showed the values of each of education and training (ET*v*) variables.

Table 9.11 The Weighting Indices (*WI*) Values of Education and Training Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
ET*v*1	0.56	19.94	23.93	08.39
ET*v*2	0.55	19.35	23.50	08.24
ET*v*3	0.65	23.11	27.78	09.74
ET*v*4	0.55	19.55	22.95	08.05
ET*v*5	(0.51)	(18.03)	-	-
Total	**2.8496 (2.3396)**	**100.00**	**100.00**	**34.42**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model which is presented in Table 9.12. This model consist of two variables. These variables included ET*v*1 (qualification, professional and further or higher education degree e.g. Ph.D, M.sc, B.sc, etc) and ET*v*4 (specific training in project management). The model has two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide a reliable classification performance.

Table 9.12 MDA Model Development for Education and Training (ET*v*) Variables Using Stepwise Method.

MDA Model No	Function No	ET*v*1	ET*v*4	Constant	Accuracy (%)
I (2-var.)					
	F1	**1.422**	**0.953**	**-10.114**	**64.70**
	F2	-0.775	1.386	-2.567	-

From the F1 model in Table 9.12, the following equation was formulated as follows:

Model Developed: (2- variables)

Function1: $\mathbf{1.422ETv1 + 0.953ETv4 - 10.114}$

The values of statistical measurement of the model was also derived and presented in Table 9.13. It was observed that F1 model provided a high Eigenvalue (0.608) that showed the characteristic of a good function when compared to the low values of F2 (0.142). The Wilk's lambda for F1 model also showed near zero values (0.544) which means that group centroids were distinctly separated between groups. The transformation of Wilk's lambda produces a significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model could be rejected. The canonical correlation of F1 model also showed a high range (0.615) which means that about 81.0 percent of the total variance was accounted for by this F1 model.

Table 9.13 The MD Statistical Results of the Model (Education and Training Variables).

MDA Model No	Function No	Eigenvalue	Wilk's Lambda				Canonical correlation
			Wilk's Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.608	0.544	28.878	4	0.000	0.615
	F2	0.142	0.875	6.320	1	0.021	0.353

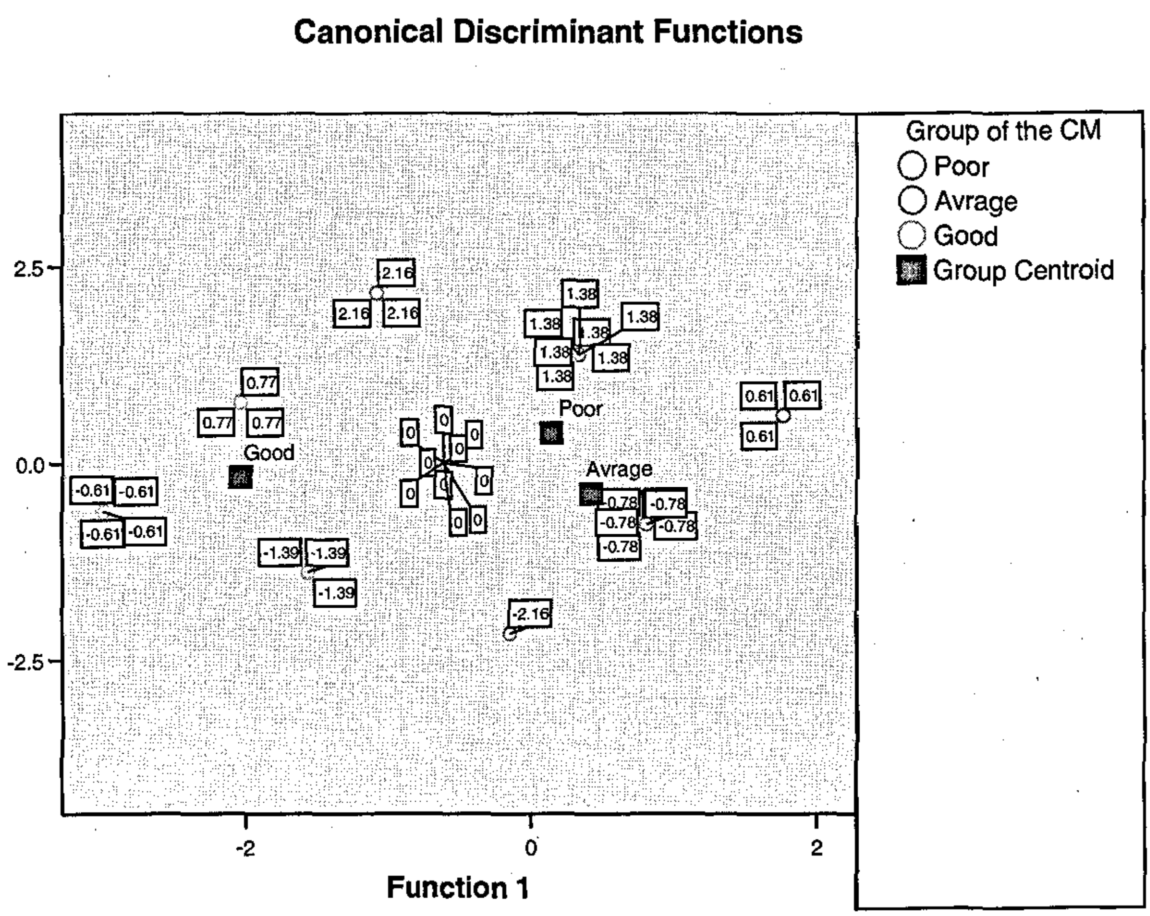
Having discriminating value F1 model, the result of classification performance using F1 equation was presented in Table 9.14.

Table 9.14 Model Performance Evaluation (Education and Training Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	**70.6**	**66.7**	**71.4**	**83.3**

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 70.6 percent. Poor CEPM's were classified at 66.7 percent accuracy. The average CEPM's were classified at 71.4 percent accuracy and good CEPM's classified at 83.3 percent accuracy. A diagrammatic representation of the classification results of the model are provided in Figure 9.3.

Figure 9.3 Classification Results of the Education and Training Variables (Two Variables- Group Centroids).



This model provided, at most, two personal variables that are acceptably accurate in classifying a CEPM's aptitude. Such variables can be formulated to form the equation:

$$CEPM's_{(AETv)} = a\ ETv1 + b\ ETv4 + K$$

Where $CEPM's_{(AETv)}$ is the CEPM's aptitude in terms of Education and Training (ET*v*) Factor, *a* and *b* are the coefficients of the variable, ET*v*1 is qualification (professional and further or higher education degree e.g. Ph.D, M.sc, B.sc, etc) and ET*v*4 is specific training in project management and K is the constant.

9.5 MANAGEMENT FACTOR: MDA CLASSIFICATION OF MANAGEMENT VARIABLES

The *WI* values further derived the percentage weight and the relative weighting index of each variable. Table 9.15 shows the values of each Management (M*v*) variable. However, Management variables (Table 9.15) all obtained *WI* values of more than 0.55. The finding suggests that all of these management variables are strong variables that would qualify for future classification analysis.

Table 9.15 The Weighting Indices (*WI*) Values of Management Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
M*v*1	0.95	09.06	09.06	0.95
M*v*2	1.00	09.50	09.50	1.00
M*v*3	0.88	08.37	08.37	0.88
M*v*4	0.96	09.12	09.12	0.96
M*v*5	0.92	08.74	08.74	0.92
M*v*6	0.82	07.80	07.80	0.82
M*v*7	0.80	07.64	07.64	0.80
M*v*8	0.77	07.37	07.37	0.77
M*v*9	0.70	06.70	06.70	0.70
M*v*10	0.72	06.89	06.89	0.72
M*v*11	0.64	06.13	06.13	0.64
M*v*12	0.70	06.68	06.68	0.70
M*v*13	0.62	05.95	05.95	0.62
Total	**10.5039**	**100.00**	**100.00**	**10.5039**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model and is presented in Table 9.16. This model consist of two variables and included M*v*3 (accountability for both projects successes and failure) and M*v*5 (an ability to control the construction process). This model has two corresponding function (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.16 MDA Model Development for Management (M*v*) Variables Using Stepwise Method.

MDA Model No	Function No	M*v*3	M*v*5	Constant	Accuracy (%)
I (2-var.)					
	F1	**1.543**	**1.178**	**-1.184**	**64.70**
	F2	0.723	-1.010	-7.566	-

Statistical measurements and results of the derived model is presented in Table 9.17. F1 values for the model provided high Eigenvalue (0.429) which characterised good function over the F2 values. The Wilks lambda for F1 showed value (0.670) which was close to zero, an indication that group centroids of F1 function were distinctly separated between groupings. The transformation of Wilks lambda of less than 0.002 showed that there was no equality of centroids of function of the model.

Table 9.17 The MD Statistical Results of the Model (Management Variables).

MDA Model No	Function No	Eigenvalue	Wilks Lambda				Canonical correlation
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.429	0.670	19.058	4	0.000	0.548
	F2	0.045	0.957	2.112	1	0.146	0.209

Using F1 function, the following equation for the model was formulated:

Model Developed: (2- variables)

$$Function1: \quad 1.543\,Mv3 + 1.178\,Mv4 - 1.184$$

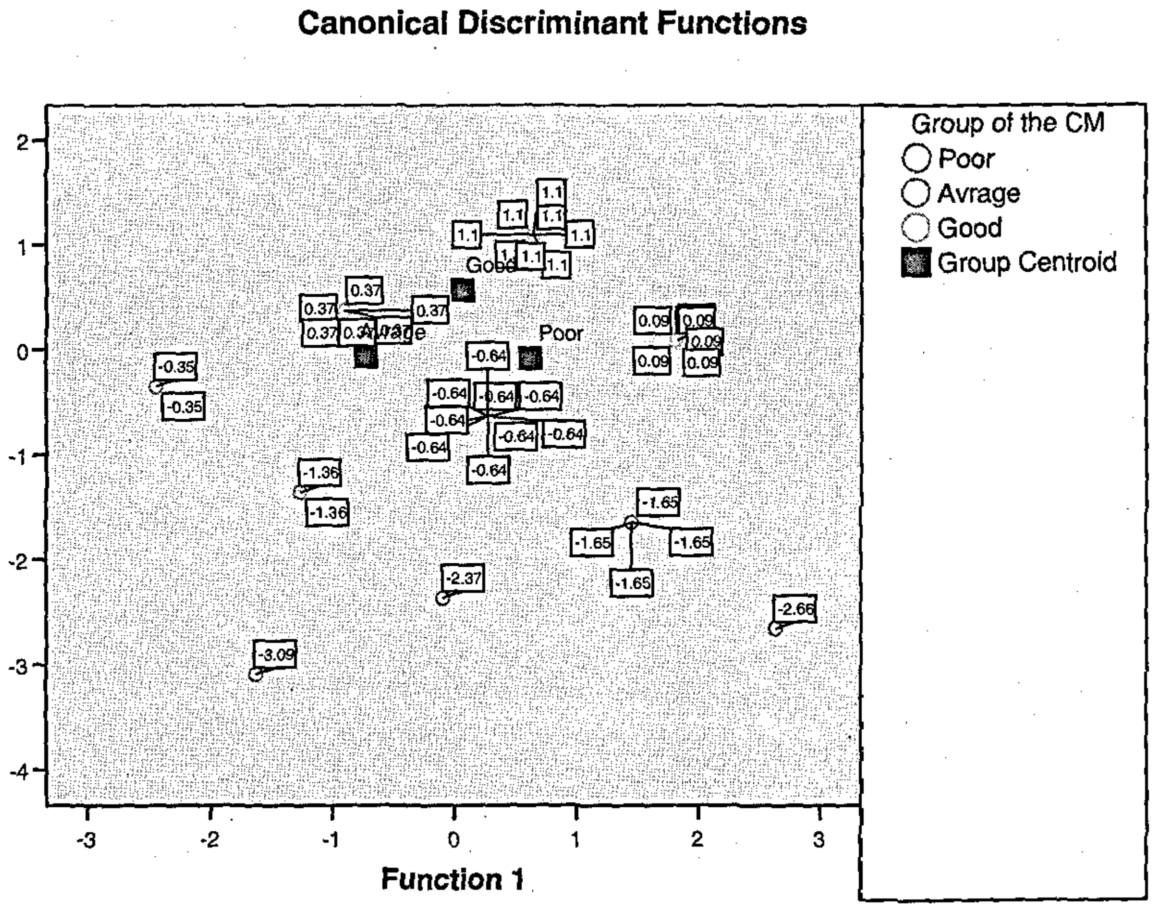
The model performance showed that CEPM's were classified at 72.5 percent accuracy. In Table 9.18, accuracy of the model is elaborated. The good CEPM's were 63.7 percent. The average CEPM's were classified at 81.0 percent and poor CEPMs were classified at 83.3 percent accuracy.

Table 9.18 Model Performance Evaluation (Management Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	72.5	83.3	81.0	63.3

A diagrammatic representation of the classification results of the model is represented in Figure 9.4.

Figure 9.4 Classification Results of the Management Variables (Two Variables-Group Centroids).



The MDA model provided, at most, two management variables that are acceptably accurate in classifying a CEPM's aptitude. Such variables can be formulated to produce the equation:

$$CEPM's_{(AMv)} = a\,ETv1 + bETv4 + K$$

Where CEPM's$_{(AMv)}$ is the civil engineering project managers aptitude in terms of Management (Mv) Factor, *a* and *b* are the coefficients of the variables, Mv3 is accountability for both projects successes and failure, Mv5 is an ability to control the construction process and K is the constant.

9.6 WORK SITUATIONAL FACTOR: MDA CLASSIFICATION OF WORK SITUATIONAL VARIABLES

The *WI* values derived the percentage weight and the relative weighting index of each variable. Table 9.19 showed the values of each of work situational (WS*v*) variables.

Table 9.19 The Weighting Indices (*WI*) Values of Work Situational Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
WS*v*1	(0.46)	(10.80)	-	-
WS*v*2	(0.54)	(12.67)	-	-
WS*v*3	0.65	15.39	19.94	04.68
WS*v*4	0.65	15.39	19.94	04.68
WS*v*5	0.69	16.32	21.17	04.97
WS*v*6	0.60	14.29	18.40	04.32
WS*v*7	0.63	14.86	19.33	04.53
Total	**4.2591 (3.2591)**	**100.00**	**100.00**	**23.18**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model and is presented in Table 9.20. This model consist of two variables and included WS*v*3 (project complexity) and WS*v*5 (an ability to ensure the health, safety and welfare of others on site). This model has two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.20 MDA Model Development for Work Situational (WS*v*) Variables Using Stepwise Method.

MDA Model No	Function No	WS*v*3	WS*v*5	Constant	Accuracy (%)
I (2-var.)					
	F1	**0.521**	**1.541**	**-4.438**	**60.80**
	F2	1.325	0.568	-8.059	-

From the F1 model in Table 9.20, the following equation was formulated as follows:

Model Developed: (2- variables)

Function1: 0.521 WSv3 + 1.541 WSv5 – 4.438

The values of statistical measurement of the model was also derived and presented in Table 9.21. It was observed that F1 model provided high Eigenvalue (0.449) that showed the characteristic of a good function when compared to the low values of F2 (0.106). The Wilks lambda for F1 model also showed near zero values (0.624) which means that group centroids were distinctly separated between groups. at the same time, the transformation of Wilks lambda determines a significance level of less than 0.000, which proved that the hypothesis of equality of centroids of the function in the above model could be rejected. The canonical correlation of F1 model also showed a high range (0.556) which means that about 80.9 percent of the total variance were being accounted for by this F1 model.

Table 9.21 The MD Statistical Results of the Model (Work Situational Variables).

MDA Model No	Function No	Eigenvalue	Wilks Lambda				Canonical correlation
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.449	0.624	22.385	4	0.000	0.615
	F2	0.106	0.904	4.781	1	0.029	0.309

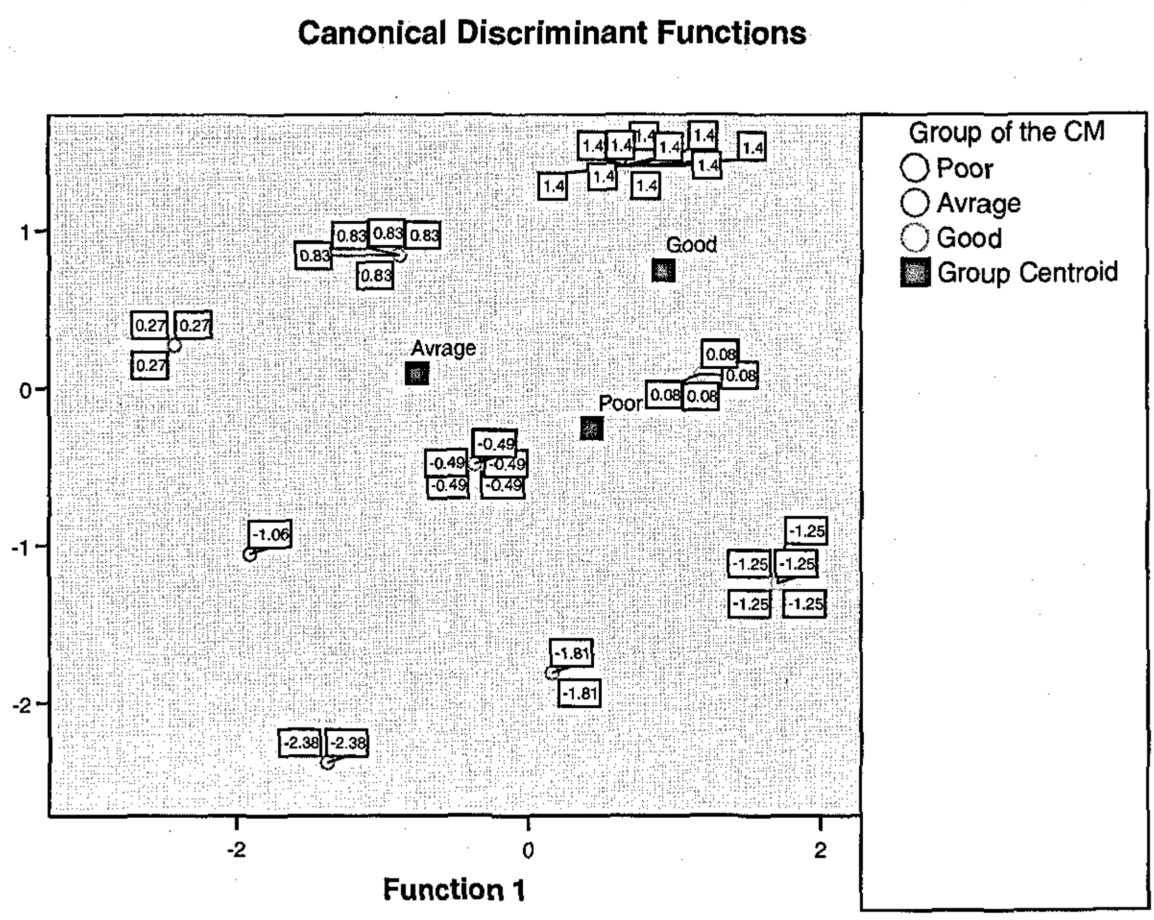
Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.22.

Table 9.22 Model Performance Evaluation (Work Situational Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	60.8	83.3	57.4	77.3

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 60.8 percent. Poor CEPM's were classified at 83.3 percent accuracy. The average CEPM's were classified at 57.4 percent accuracy and good CEPM's classified at 77.3 percent accuracy. A diagrammatic representation of the classification results of the model are presented in Figure 9.5.

Figure 9.5 Classification Results of the Management Variables (Two Variables-Group Centroids)



The MDA model provided, at most, two work situational variables that are acceptably accurate in classifying the CEPM's aptitude. Such variables can be formulated to form the equation:

$$CEPM's_{(AWSv)} = a\ WSv3 + b\ WSv5 + K$$

Where CEPM's$_{(AWSv)}$ is the civil engineering project manager's aptitude in terms of Work Situational (WS*v*) Factor, *a* and *b* are the coefficients of the variables, WS*v*3 is project complexity, WS*v*5 is an ability to ensure the health, safety and welfare of others on site and K is the constant.

9.7 PROJECT QUALITY CONTROL FACTOR: MDA CLASSIFICATION OF PROJECT QUALITY CONTROL VARIABLES

The *WI* values further derived the percentage weight and the relative weighting index of each variable. Table 9.23 shows the values of each of project quality control (QC*v*) variables. However, project quality control variables (Table 9.23) all obtained *WI* values of more than 0.55. The finding suggests that all of these project quality control (QC*v*) variables are strong variables that would qualify for future classification analysis.

Table 9.23 The Weighting Indices (*WI*) Values of project quality control Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
QC*v*1	0.70	13.84	13.84	00.70
QC*v*2	0.58	11.43	11.43	00.58
QC*v*3	0.64	12.76	12.76	00.64
QC*v*4	0.63	12.50	12.50	00.63
QC*v*5	0.66	13.13	13.13	00.66
QC*v*6	0.63	12.59	12.59	00.63
QC*v*7	0.62	12.24	12.24	00.62
QC*v*8	0.58	11.47	11.47	00.58
Total	**5.0727**	**100.00**	**100.00**	**5.0727**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model that is presented in Table 9.24. This model consist of two variables which included QCv1 (ensuring project quality in order to achieve customer satisfaction) and QCv4 (translating expectations into specific deliverables to meet customer requirements). This model has two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.24 MDA Model Development for Project Quality Control (QCv) Variables Using Stepwise Method.

MDA Model No	Function No	QCv1	WSv4	Constant	Accuracy (%)
I (2-var.)					
	F1	**0.966**	**0.946**	**-8.233**	**58.80**
	F2	-1.017	1.500	-1.905	-

From the F1 model in Table 9.24, the following equation was formulated as follows:

Model Developed: (2- variables)

$$\textit{Function1:} \quad 0.966\,QCv1 + 0.946\,QCv4 - 8.233$$

The values of statistical measurement of the model was also derived and presented in Table 9.25. It was observed that F1 model provided high Eigenvalue (0.304) that showed the characteristic of a good function when compared to the low values of F2 (0.044). The Wilks lambda for F1 model also showed near zero values (0.813) which means that group centroids were distinctly separated between groups. The transformation of Wilks lambda determines the significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model could be rejected. The canonical correlation of F1 model also showed a high range (0.483) which means that about 87.3 percent of the total variance were being accounted for by this F1 model.

Table 9.25 The MD Statistical Results of the Model (Project Quality Control Variables).

MDA Model No	Function No	Eigenvalue	Wilks Lambda				Canonical correlation
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.304	0.735	14.649	4	0.000	0.483
	F2	0.044	0.958	4.781	1	0.152	0.206

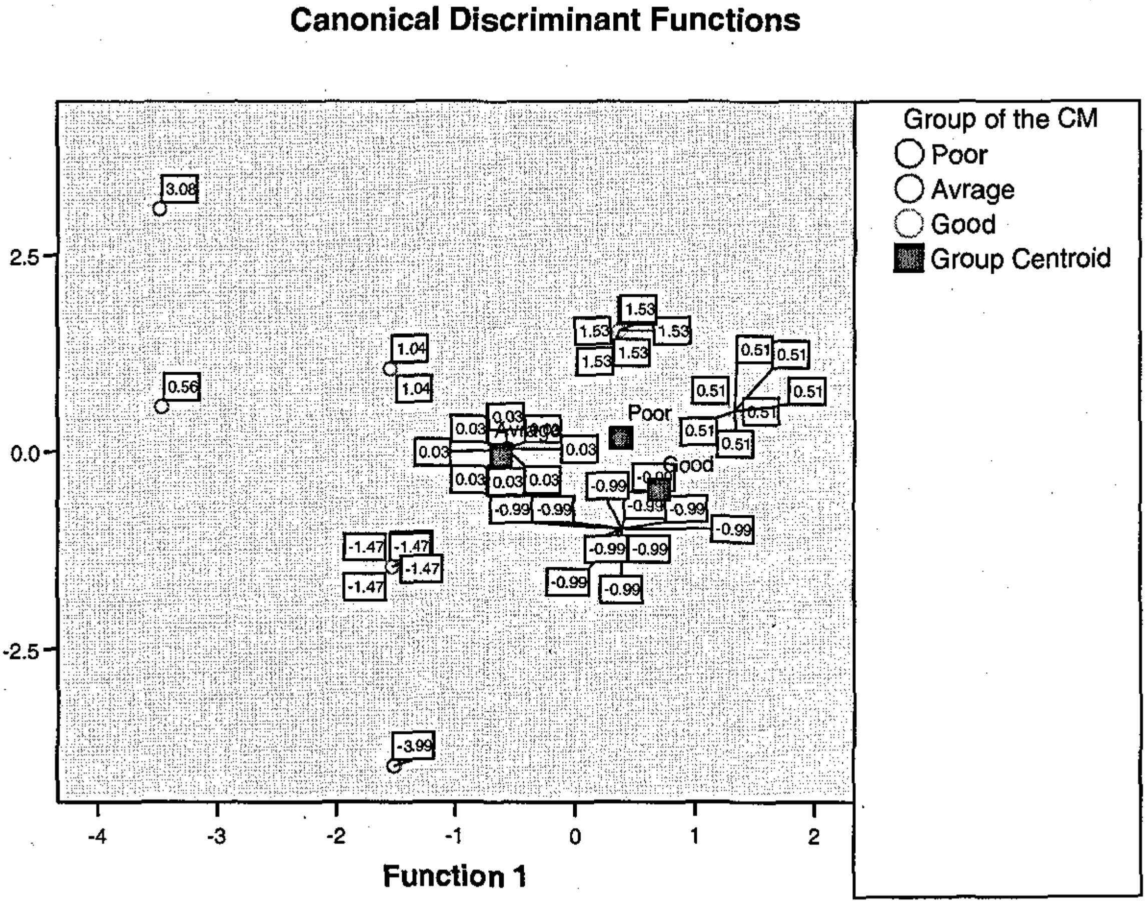
Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.26.

Table 9.26 Model Performance Evaluation (Project Quality Control Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	**77.8**	**70.8**	**66.9**	**73.3**

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 77.8 percent. Poor CEPM's were classified at 70.8 percent accuracy. The average CEPM's were classified at 66.9 percent accuracy and good CEPM's were classified at 73.3 percent accuracy. A diagrammatic representation of the classification results of the model presented in Figure 9.6.

Figure 9.6 Classification Results of the Project Quality Control Variables (Two Variables- Group Centroids).



The MDA model provided, two project quality control variables that are acceptably accurate in classifying the CEPM's aptitude. These variables are used to formulate the equation:

$$CEPM's_{(AQCv)} = a\ QCv1 + bQCv4 + K$$

Where CEPM's$_{(AQCv)}$ is the civil engineering project manager's aptitude in terms of the Project Quality Control (QC*v*) Factor, *a* and *b* are the coefficient of the variable, QC*v*1 is ensuring project quality in order to achieve customer satisfaction, QC*v*4 is translating expectations into specific deliverables to meet customer requirements and K is the constant.

9.8 PLANNING FACTOR: MDA CLASSIFICATION OF PLANNING VARIABLES

The *WI* values further derived the percentage weight and the relative weighting index of each variable. Table 9.27 showed the values of each of planning (PL*v*) variables.

Table 9.27 The Weighting Indices (*WI*) Values of Planning Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
PL*v*1	0.66	18.22	21.05	05.74
PL*v*2	0.65	17.81	20.73	05.65
PL*v*3	0.66	18.15	21.05	05.74
PL*v*4	0.56	15.46	17.86	04.87
PL*v*5	0.57	15.70	18.18	04.96
PL*v*6	(0.53)	(14.62)	-	-
Total	**3.6641 (3.1341)**	**100.00**	**100.00**	**26.96**

Note: variables in parenthesis () are excluded-results showed weak variables.

The MDA classification technique derived one model and is presented in Table 9.28. This model consist of two variables which included PL*v*1 (scheduling key project activities at completion of the project design phase) and PL*v*5 (quality materials selection and storage of these on site). This model has two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.28 MDA Model Development for Planning Variables Using Stepwise Method.

MDA Model No	Function No	PL*v*1	PL*v*5	Constant	Accuracy (%)
I (2-var.)					
	F1	**1.062**	**1.101**	**0.167**	**68.60**
	F2	-1.101	-1.187	-8.534	-

From the F1 model in Table 9.28, the following equation can be formulated as follows:

Model Developed : (2- variables)

$$\textit{Function1:} \quad 1.062\, PLv1 + 1.101\, PLv5 + 0.167$$

The values of statistical measurement of the model were also derived and presented in Table 9.29. It was observed that the F1 model provided a high Eigenvalue (0.562) that showed the characteristic of a good function when compared to the low values of F2 (0.050). The Wilks lambda for F1 model also showed near zero values (0.620) which means that group centroids were distinctly separated between groups. The transformation of Wilks lambda determined significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model is rejected. The canonical correlation of F1 model also showed a high range (0.673) which means that about 76.5 percent of the total variance were being accounted for by this F1 model.

Table 9.29 The MD Statistical Results of the Model (Project Planning Variables).

MDA Model No	**Function No**	**Eigenvalue**	**Wilks Lambda**				**Canonical correlation**
			Wilks Lambda	chi-squared	df	Sig	
I (2-var.)							
	F1	0.562	0.620	9.437	4	0.000	0.612
	F2	0.007	0.953	0.305	1	0.050	0.018

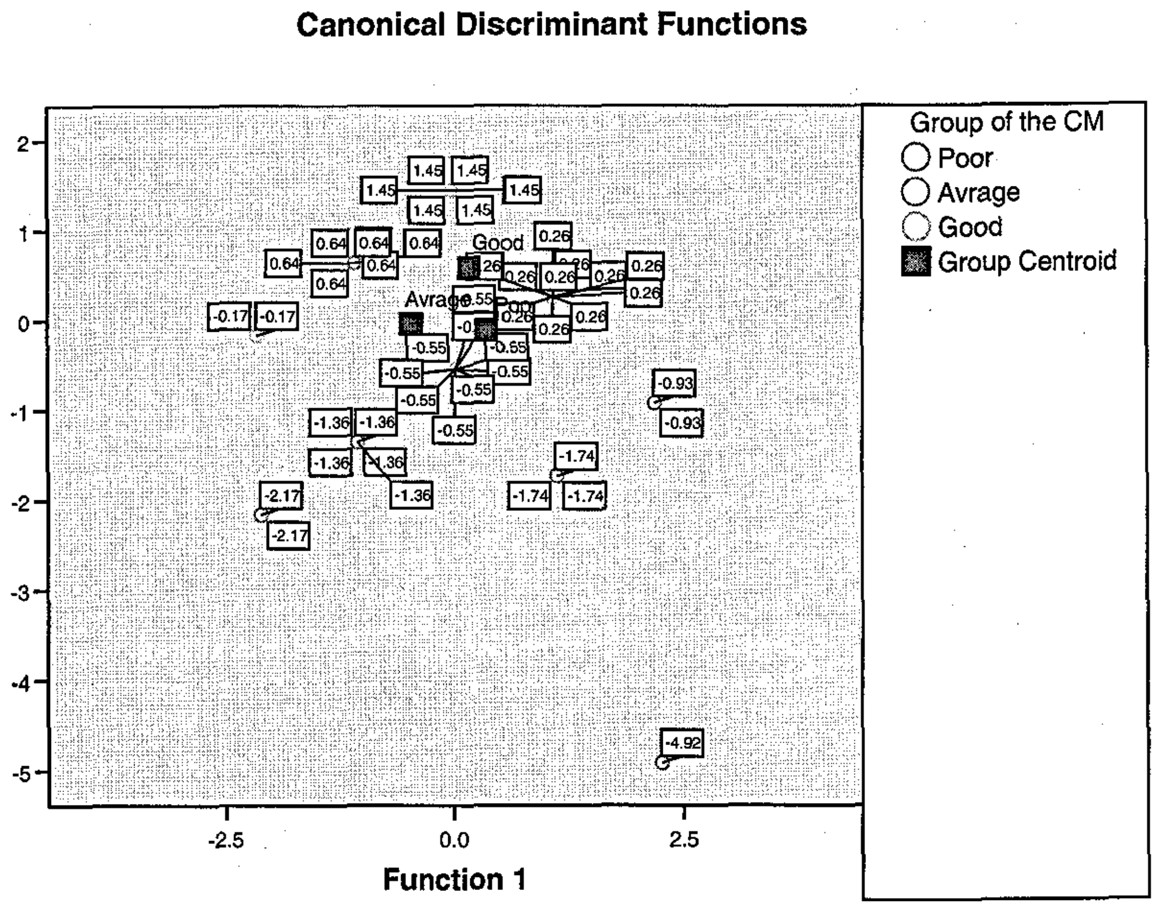
Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.30.

Table 9.30 Model Performance Evaluation (Project Planning Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (2-var.)	66.7	75.8	70.4	63.5

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 66.7 percent. Poor CEPM's were classified at 75.8 percent accuracy. The average CEPM's were classified at 70.4 percent accuracy and good CEPM's classified at 63.5 percent accuracy. Next diagrammatic representation of the classification results of the model is presented in Figure 9.7.

Figure 9.7 Classification Results of the Project Planning Variables (Two Variables-Group Centroids).



The MDA model provided, at most, two project planning variables that are acceptably accurate in classifying CEPM's aptitude. These variables are formulated to produce the equation:

$$\boldsymbol{CEPM's_{(APLv)} = a\,PLv1 + bPLv5 + K}$$

Where CEPM's $_{(APLv)}$ is the civil engineering project manager's aptitude in terms of Planning (PLv) Factor, a and b are the coefficients of the variables, PLv1 is scheduling key project activities at completion of the project design phase, PLv5 is quality materials selection and storage of these on site and K is the constant.

9.9 SUMMARY OF MDA CLASSIFICATION PROCEDURE OF SEVEN FACTORS

After the exclusion of the weak variables, forty six (46) variables had been subjected for classification procedure. The MDA classification technique derived fourteen (14) variables to form another definitive profile of a good CEPM (Table 9.31). The fourteen variables can be considered the appropriate predictors in determining CEPM's aptitude.

Table 9.31 Summary of MDA Classification Results of Seven Factors.

Factor	Variable	Description
Personal	Pv4	Personal Disposition.
Personal	Pv10	Cooperative e.g. helpful and able to work with others.
Motivation	Bv4	Team-based bonus for timely project completion.
Motivation	Bv6	Job promotion opportunities.
Education and Training	ETv1	Qualification (PhD, Msc, Bsc, etc.
Education and Training	ETv4	Specific training in project management.
Management	Mv3	Accountability for both projects successes and failure.
Management	Mv5	An ability to control the construction process.
Work Situation	WSv3	Project complexity.
Work Situation	WSv5	An ability to ensure the health, safety and welfare of others on site.
Project Quality Control	QCv1	Ensuring project quality in order to achieve customer satisfaction.
Project Quality Control	QCv4	Translating expectations into specific deliverables to meet customer requirements.
Planning	PLv1	Scheduling key project activities at completion of the project design phase.
Planning	PLv5	Quality materials selection and storage of these on site.
Total Number of Variables	**14 Variables**	

Having derived these 14 variables, there is a need to compare them with the results obtained in the profile of CEPM's aptitude (Chapter 8). Such a comparison guided this research on the variables that have impacted upon the results findings. Table 9.32 is presented to show profile and MDA findings.

Table 9.32 Comparison of Profile and Results of MDA Classification of Seven Factors of Civil Engineering Project Manager's Aptitude.

No	Results of Profile (Table 8.11)	Results of MDA Classification (Table 9.31)	No
01-	Mv2	Pv4*	01-
02-	Mv4	Pv10*	02-
03-	Mv1	Bv4*	03-
04-	Mv5*	Bv6*	04-
05-	Mv3*	ETv1*	05-
06-	Mv6	ETv4*	06-
07-	Pv6	Mv3 *	07-
08-	Pv5	Mv5*	08-
09-	Mv7	WSv3*	09-
10-	Pv7	WSv5 *	10-
11-	Mv8	QCv1*	11-
12-	Pv9	QCv4*	12-
13-	Pv10*	PLv1*	13-
14-	Mv10	PLv5*	14-
15-	Mv9		
16-	Pv4*		
17-	Mv12		
18-	QCv1*		
19-	Pv8		
20-	WSv5*		
21-	PLv1*		
22-	QCv5		
23-	PLv3		
24-	Bv6*		
25-	ETv3		
26-	WSv3*		
27-	WSv4		
28-	PLv2		
29-	QCv3		
30-	Mv11		
31-	QCv6		
32-	QCv4*		
33-	WSv7		
34-	Bv1		
35-	Mv13		
36-	QCv7		
37-	Bv3		
38-	WSv6		
39-	QCv8		
40-	QCv2		
41-	PLv5*		
42-	Bv4*		
43-	ETv1*		
44-	PLv4*		
45-	ETv4		
46-	ETv2		

The profile results derived (46) variables while MDA classification technique derived (14) variables. This means that both methods considered suggested that these variables are very strong predictors of the ideal CEPM. At this point of the study, it can be hypothesised that the 14 variables are the best predictor variables to determine CEPM's aptitude. These variables are Pv4 (Personal Disposition) and Pv10 (Cooperative e.g. helpful and able to work with others) form the Personal Factor (Pv), Bv4 (Team-based bonus for timely project completion) and Bv6 (Job promotion opportunities) from Motivation Factor (Bv), ETv1 Qualification (PhD, Msc, Bsc, etc) and ETv4 (Specific training in project management) from Education and Training Factor (ETv), Mv3 (Accountability for both projects successes and failure) and Mv5 (An ability to control the construction process) from Management Factor (Mv), WSv3 (Project complexity) and WSv5 (An ability to ensure the health, safety and welfare of others on site) from Work Situation Factor (WSv), QCv1 (Ensuring project quality in order to achieve customer satisfaction) and QCv4 (Translating expectations into specific deliverables to meet customer requirements) from Project Quality Control Factor (QCv) and PLv1 (Scheduling key project activities at completion of the project design phase) and PLv5 (Quality materials selection and storage of these on site) from Planning Factor (PLv).

9.10 SUMMARY OF MDA CLASSIFICATION PROCEDURE OF GENERAL MDA

After derived the most important variables that impact upon the CEPMs aptitude (using weight index and MDA) for each factor in a separate analysis, it was decided to look at factors together. It was felt that every drop of knowledge had been extracted from the analysis and that now, a summery was required to simplify the final model. Table 9.33 showed the values of each of general MDA variables. However, general classification variables all obtained WI values of more than 0.55. the finding suggests that all of these variables are strong variables.

Table 9.33 The Weighting Indices (*WI*) Values of general MDA Variables.

Variable Code	*WI* Values	Percentage Weight (%)	Corrected Percentage Weight (%)	Weight Index (relative %)
Bv5	0.57	18.32	18.32	00.57
ETv2	0.55	17.68	17.68	00.55
ETv3	0.65	20.90	20.90	00.65
PLv2	0.65	20.90	20.90	00.65
WSv5	0.69	22.18	22.18	00.69
Total	**3.11**	**100.00**	**100.00**	**3.112**

Note: variables in parenthesis () are excluded-results showed weak variables.

The general MDA classification technique derived one model that is presented in Table 9.34. this model consist of five (5) variables which included B*v*4 (Team-based bonus for timely project completion); ET*v*2 (specific vocational background); ET*v*3 (practical building knowledge and experience); PL*v*2 (recognition of the interdependence of the project activities) and WS*v*5 (An ability to ensure the health, safety and welfare of others on site). The five variables can be considered the appropriate predictors in determining the CEPM's aptitude. Table 9.36 shows the findings of the general classification models and the comparison with profile and MDA for the seven factors. This model has two corresponding functions (F1 and F2) of which F2 was disregarded because it did not provide reliable classification performance.

Table 9.34 General MDA Model Development Using Stepwise Method.

MDA Model No	Function No	WSv5	ETv3	PLv2	Bv4	ETv2	Constant	Accuracy (%)
I (5-var.)								
	F1	**0.100**	**-1.407**	**1.289**	**0.310**	**0.554**	**-4.012**	**84.80**
	F2	1.605	-0.290	0.790	-1.409	0.979	-6.737	-

From the F1 model in Table 9.34, the following equation can be formulated as follows:

Model Developed : (5- variables)

Function1: ***0.100 WSv5 + 1.407 ETv3 + 1.289 PLv2 + 0.310 Bv4 +0.554 ETv2 + 4.012***

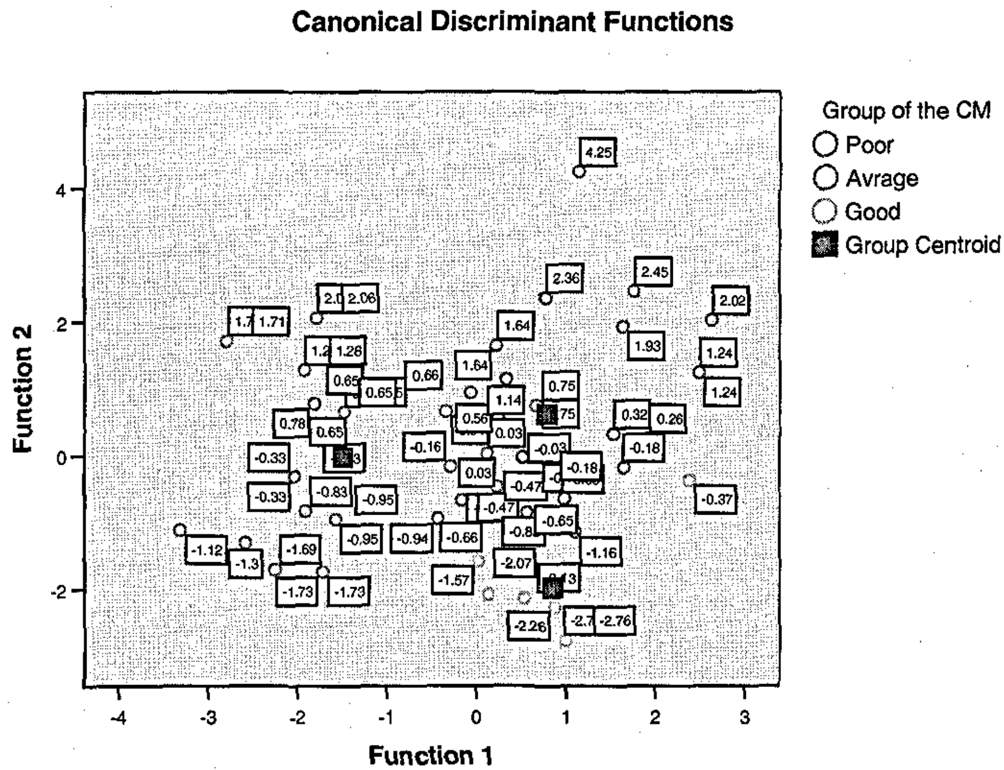
The values of statistical measurement of the model were also derived and presented in Table 9.35. It was observed that the F1 model provided a high Eigenvalue (0.750) that showed the characteristic of a good function when compared to the low values of F2 (0.0678). The Wilks lambda for F1 model also showed near zero values (0.237) which means that group centroids were distinctly separated between groups. The transformation of Wilks lambda determined significance level of less 0.000, which proved that the hypothesis of equality of centroids of the function in the above model is rejected. The canonical correlation of F1 model also showed a high range (0.750) which means that about 75.0 percent of the total variance were being accounted for by this F1 model.

Table 9.35 The MDA Statistical Results of the General Model Variables.

MDA Model No	**Function No**	**Eigenvalue**	**Wilks Lambda**				**Canonical correlation**
			Wilks Lambda	chi-squared	df	Sig	
I (5-var.)							
	F1	1.283	0.237	59.097	10	0.000	0.750
	F2	0.851	0.540	25.250	4	0.030	0.678

Having discriminating value F1 model, the result of classification performance using F1 equation is presented in Table 9.36. A diagrammatic representation of the classification results of the model is presented in Figure 9.8.

Figure 9.8 Classification Results of the General MDA Variables (Five Variables-Group Centroids).



The final models developed can be expressed as:.

The general MDA model provided, at most, two management variables that are acceptably accurate in classifying a CEPM's aptitude. Such variables can be formulated to produce the equation:

$$CEPM's_{(AGM)} = a\ WSv5 + b\ ETv3 + c\ PLv2 + d\ Bv4 + e\ ETv2 + K$$

Where: $CEPM's_{(AGM)}$ is the civil engineering project manager's aptitude, Bv4 (Team-based bonus for timely project completion); ETv2 (specific vocational background); ETv3 (practical building knowledge and experience); PLv2 (recognition of the interdependence of the project activities) and WSv5 (An ability to ensure the health, safety and welfare of others on site).

Table 9.36 Model Performance Evaluation (General MDA Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (5-var.)	**84.8**	**82.6**	**87.6**	**85.7**

The model performance showed that CEPM's were classified accurately by the model at an overall accuracy of 84.8 percent. Poor CEPM's were classified at 82.6 percent accuracy. The average CEPM's were classified at 87.6 percent accuracy and good CEPM's classified at 85.7 percent accuracy.

Table 9.37 Comparison of Profile, Results of MDA Classification of Seven Factors and General MDA.

No	Results of Profile (Table 8.11)	Results of MDA Classification (Table 9.31)	No	Results of General MDA Classification	No
01-	Mv2	Pv4*	01-	Bv4**	01-
02-	Mv4	Pv10*	02-	ETv2*	02-
03-	Mv1	Bv4*	03-	ETv3*	03-
04-	Mv5*	Bv6*	04-	WSv5**	04-
05-	Mv3*	ETv1*	05-	PLv2*	05-
06-	Mv6	ETv4*	06-		
07-	Pv6	Mv3 *	07-		
08-	Pv5	Mv5*	08-		
09-	Mv7	WSv3*	09-		
10-	Pv7	WSv5 *	10-		
11-	Mv8	QCv1*	11-		
12-	Pv9	QCv4*	12-		
13-	Pv10*	PLv1*	13-		
14-	Mv10	PLv5*	14-		
15-	Mv9				
16-	Pv4*				
17-	Mv12				
18-	QCv1*				
19-	Pv8				
20-	WSv5*				
21-	PLv1*				
22-	QCv5				
23-	PLv3				
24-	Bv6*				
25-	ETv3				
26-	WSv3*				
27-	WSv4				
28-	PLv2				
29-	QCv3				
30-	Mv11				
31-	QCv6				
32-	QCv4*				
33-	WSv7				
34-	Bv1				
35-	Mv13				
36-	QCv7				
37-	Bv3				
38-	WSv6				
39-	QCv8				
40-	QCv2				
41-	PLv5*				
42-	Bv4*				
43-	ETv1*				
44-	PLv4*				
45-	ETv4				
46-	ETv2				

9.10 SUMMARY

This chapter presented the results of a classification procedure based upon the MDA technique. Findings reveal that the variables that impacted on the CEPM's aptitude could be used to produce models that accurately classify aptitude into distinct groups of good, average and poor. Results derived from the classification analysis were then compared to the results obtained from the profile variables of chapter 8 and the variables obtained from the MDA classification to the seven factors. The comparison provided 5 commonly identified key predictor variables. With MDA and profile classification procedure, five (5) variables were derived to form the general model which could be expressed as:

$$\textbf{CEPM's}_{(AGM)} = 0.100\ WSv5 + 1.407\ ETv3 + 1.289\ PLv2 + 0.310\ Bv4 + 0.554\ ETv2 + 4.012$$

Where: ***CEPM's*** $_{(AGM)}$ is the civil engineering project manager's aptitude, *0.100, 1.407, 1.289, 0.310 and 0.555* are the model co-efficient values and WS*v*5 (An ability to ensure the health, safety and welfare of others on site); ET*v*3 (practical building knowledge and experience); PL*v*2 (recognition of the interdependence of the project activities); B*v*4 (Team-based bonus for timely project completion) and ET*v*2 (specific vocational background).

CHAPTER _10_
Research _ Validation

10.0 INTRODUCTION

The final stage of MDA involves validating the discriminate results to provide assurances that the findings (results) have external as well as internal validity. With the propensity of MDA to inflate the hit ratio if evaluated only on the analysis sample, cross-validation is an essential step. However, one can cross-validate by employing an additional sample as a hold-out sample or by profiling the groups on an additional set of variables.

The justification for dividing the sample into two groups is that an upward bias will occur in the prediction accuracy of the discriminate function if the individuals used in developing the classification matrix are the same as those used in computing the function. The implications of this upward bias is particularly important when attempting to justify the external validity of the findings.

10.1 VALIDATION OF THE RESEARCH FINDINGS

In the last chapter, a 75 percent sample of the data gathered was used to produce a MDA classification model. This model was able to classify CEPM's aptitude into distinct groups of good, average and poor categorise with commendable accuracy. Each of the generic factors (and variables within them) were able to derive at least one classification models that were compared to the CEPM's aptitude profile from chapter 8. The comparison allowed the identification of key variables that, would enable an accurate model to be developed. Based on that the general model was obtained.

As part of a robust validation process, two approaches of validation were undertaken to investigate these findings. The first approach of validation was the utilisation of quantitative procedure where statistical methods and calculation were used to derive values to measure the validity of the developed models. The second approach was the qualitative procedure where a small random of different range of Construction and Civil Engineering Company (C&CEC) were asked to provide comments and feedback on the research findings.

10.2 QUANTITATIVE VALIDATION

In this approach, three methods were undertaken to provide proof of validity. The first method of validation was undertaken by using a separate MDA classification technique to the 25 percent hold-out sample data. The procedure was similar to that process used to develop MDA models in the last chapter. The 25 percent hold-out sample results were then compared with the 75 percent data sample results.

The second quantitative validation procedure used a one-sample t-test procedure to test whether there was any significant difference between means of the actual and predicted classification values obtained from the 25 percent hold-out sample models. Flemming and Nellis (1997), discussed the importance of using a t-test when testing the significance difference of two samples derived from the same population. In this study, a one-sample t-test was used to validate if group classification between the actual group differed from that of the predicted group. The validity of the derived models can be conformed when mean values of actual and predicted group classification are proven to be without significant difference or close to zero. The one sample t-test works well with this kind of data because it will eliminate the variability from the predicted group against the actual group, thereby the test concentrates on the differences of the means (Siegel and Morgan, 1996).

10.1.2 MDA Classification Technique: Utilising the 25 Percent Hold-Out Sample

Having obtained a sufficient number of data (17 hold-out questionnaires), this study provided a strong statistical inference using the MDA classification modelling technique (Sekaran, 1992). It was proferred that this method alone could prove the validity of models derived when results show similar findings to the 75 percent sample data. The MDA validation results of all the derived models for each generic factor are presented in Tables 10.1 to 10.8.

From a quantitative perspective, it was observed that the models derived for each factor do not differ in their accuracy rating performance. These finding showed consistency of results, hence, the performance evaluation of all the models are very accurate when the 25 percent sample data was analysed.

Table 10.1 Model Performance Evaluation (Personal Variables) P*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
Pv4/Pv10	68.6	75.0	81.0	66.70

Table 10.2 Model Performance Evaluation (Motivation Variables) B*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
Bv4/Bv6	64.7	83.3	71.4	50.0

Table 10.3 Model Performance Evaluation (Education and Training Variables) ET*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
ETv1/ETv4	70.6	66.7	71.4	83.3

Table 10.4 Model Performance Evaluation (Management Variables) M*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
Mv3/Mv5	72.5	83.3	81.0	63.3

Table 10.5 Model Performance Evaluation (Work Situational Variables) WS*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
WSv3/WSv5	60.8	83.3	57.4	77.3

Table 10.6 Model Performance Evaluation (Project Quality Control Variables) QC*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
QCv1/QCv4	**77.8**	**70.8**	**66.9**	**73.3**

Table 10.7 Model Performance Evaluation (Planning Variables) PL*v*.

MDA Model	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
PLv1/PLv5	**66.7**	**75.8**	**70.4**	**63.5**

Table 10.8 Model Performance Evaluation (General MDA Variables).

MDA Model No	Over-all classification Accuracy (%)	Accuracy in classification poor CEPM (%)	Accuracy in classification average CEPM (%)	Accuracy in classification good CEPM (%)
I (5-var.)				
WS*v*5, ET*v*3, PL*v*2, B*v*4 ET*v*2	**84.8**	**82.6**	**87.6**	**85.7**

10.2 Comparison of MDA Performance: 75 Percent Vs. 25 Percent

Having considered the acceptability of the model performance using the *25* percent data sample, the findings were then compared to those obtained from the *75* percent sample. In Table 10.9, the model performance evaluation of both results is tabulated for easy comparison.

The results for both (*75%* and *25%* samples) are highly similar. Hence, these results showed good indications that the derived models were valid for industry utilisation. The general model was evaluated and also found out to provide a convincing validity. The next equation was derived the general model:

$$CEPM's_{(AGM)} = a\ WSv5 + b\ ETv3 + c\ PLv2 + d\ Bv4 + e\ ETv2 + K$$

Where: ***CEPM's*** $_{(AGM)}$ is the civil engineering project manager's aptitude, B*v*4 (Team-based bonus for timely project completion); ET*v*2 (specific vocational background); ET*v*3 (practical building knowledge and experience); PL*v*2 (recognition of the interdependence of the project activities) and WS*v*5 (An ability to ensure the health, safety and welfare of others on site).

Having determined the general model was the appropriate, it was subsequently recommended that the findings be reported and disseminated to the industry practitioners in order to obtain constructive feedback and comments. At the same time, these feedback and comments conveyed the qualitative validation of this research which formed the second approach of this validation. Tables 10.9 shows the comparative between the MDA classification techniques results in both cases 75 percent and 25 percent.

Table 10.9 Model Performance Evaluation 75 % vs. 25 % Sample Data.

MDA Model	Over-all classification Accuracy (%)		Accuracy in classification poor CEPM (%)		Accuracy in classification average CEPM (%)		Accuracy in classification good CEPM (%)	
	75%	25%	75%	25%	75%	25%	75%	25%
Personal Variables (P*v*)								
i. *Pv4, Pv10*	68.6	69.3	75.0	74.7	81.0	79.3	66.7	65.7
Motivation Variables (B*v*)								
ii. *Bv4, Bv6*	64.7	72.5	83.3	79.2	71.4	71.4	57.7	55.3
Education & Training Variables (ET*v*)								
iii. *ETv1, ETv4*	70.6	68.6	66.7	65.7	71.4	70.3	83.3	79.7
Management Variables (M*v*)								
iv. *Mv3, Mv5*	72.6	70.6	83.3	81.7	81.0	80.0	63.3	61.7
Work Situational Variables (WS*v*)								
v. *WSv3, WSv5*	60.0	60.1	83.3	79.7	57.4	59.7	77.3	76.8
Project Quality Control Variables (QC*v*)								
vi. *QCv1, QCv4*	77.8	73.3	70.8	71.2	66.9	63.3	73.3	77.0
Planning Variables (PL*v*)								
vii. *PLv1, PLv5*	66.7	69.3	75.8	71.7	70.4	69.9	63.5	65.7
General Model viii. WS*v*5, ET*v*3, PL*v*2, B*v*4 ET*v*2	84.8	76.2	82.6	73.3	87.5	75.0	85.7	82.3

10.3 The One Sample T-Test Validation (25 Percent Sample)

The one sample t-test was conducted to test the hypotheses about the means of actual group classification and predicted group classification. In the next sub-sections, the statistical results of the one sample t-test of each of the seven factors and the general model are discussed and presented.

Table 10.10 One Sample T-test Statistical Results.

Grouping Classification		Paired Differences Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper	t	df	Sig. (2-tailed)
Personal Variables (Pv)									
Good	Actual-Predicted	0.0181	0.2209	0.0398	-0.0763	0.1871	1.001	21	0.312
Average	Actual-Predicted	-0.0437	0.4009	0.0798	-0.1763	0.0871	-0.776	37	0.433
Poor	Actual-Predicted	-0.6153	0.4989	0.1998	-0.8763	-0.3271	-3.776	14	0.017
Motivation Variables (Bv)									
Good	Actual-Predicted	0.1520	0.3987	0.0898	-0.0203	0.3871	1.776	21	0.102
Average	Actual-Predicted	-0.0177	0.4388	0.0598	-0.2141	0.0779	-2.003	37	0.211
Poor	Actual-Predicted	-0.6217	0.5209	0.0997	-0.8063	0.4219	-3.205	14	0.009
Education & Training Variables (ETv)									
Good	Actual-Predicted	0.0957	0.3321	0.0664	-0.0391	0.3321	0.082	21	0.132
Average	Actual-Predicted	-0.0332	0.4555	0.0528	-0.1130	0.1276	0.065	37	0.821
Poor	Actual-Predicted	-0.2587	0.4281	0.1003	-0.5832	0.0881	0.128	14	0.098
Management Variables (Mv)									
Good	Actual-Predicted	0.1553	0.3544	0.0977	-0.0329	0.4007	1.776	21	0.092
Average	Actual-Predicted	-0.1199	0.5709	0.0812	-0.3376	0.0441	-1.661	37	0.129
Poor	Actual-Predicted	-0.0767	0.2881	0.0677	-0.2544	0.0861	-1.221	14	0.400
Work Situational Variables (WSv)									
Good	Actual-Predicted	0.1440	0.3379	0.0778	0.0204	0.3063	1.870	21	0.088
Average	Actual-Predicted	-0.1293	0.2997	0.0813	-0.2008	0.1077	-0.826	37	0.387
Poor	Actual-Predicted	-0.3029	0.4209	0.0559	-0.4763	0.0663	-1.654	14	0.098
Project Quality Control Variables (QCv)									
Good	Actual-Predicted	0.1520	0.3987	0.0898	-0.0203	0.4171	1.776	21	0.102
Average	Actual-Predicted	-0.1199	0.5709	0.0812	-0.3376	0.0441	-1.661	37	0.201
Poor	Actual-Predicted	-0.6217	0.5209	0.0997	-0.8063	0.4249	-3.235	14	0.009
Planning Variables (PLv)									
Good	Actual-Predicted	0.1621	0.3987	0.0798	-0.0193	0.2871	1.776	21	0.122
Average	Actual-Predicted	-0.1189	0.5709	0.0812	-0.3376	0.0541	-1.661	37	0.117
Poor	Actual-Predicted	-0.6153	0.4989	0.1998	-0.8763	-0.3271	-3.776	14	0.019
General Model									
Good	Actual-Predicted	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	21	0.000
Average	Actual-Predicted	-0.0312	0.3565	0.0429	-0.1210	0.2031	0.055	37	0.561
Poor	Actual-Predicted	-0.4128	0.3172	0.0433	-0.5029	0.0719	-2.031	14	0.032

Statistical result findings of 25 percent holdout sample are presented in Table 10.10. The results showed that at the 95 percent confidence interval, the p-value (sig. e tailed) associated with the t-statistics values in each of the classification model showed that there is no significant difference of predicted groups to actual groups classification. Based on these findings that the first (re-analysis 25%) and the second (t-test between predicted and actual groups) elements of the first approach of validation was conformed and reinforced the derived models for all the factors including the derivation of the general model.

10.4 QUALITATIVE VALIDATION

The second approach of validation was undertaken using the collective comments and feedback of participating construction and civil engineering professional and practitioners (including representatives from construction industry). The results and findings were consolidated into a report format and translated into layman's terms in order that target respondents can easily understand the result findings. These respondents had previously subscribed to be informed about the research survey findings.

The feedback and comments were generally positive with agreement to the findings of this study. They conformed that the classification model had accurately identified the least number of variables necessary to determine the quality of a good construction project manage (CEPM). From this feedback, there is a very strong evidence that variables identified will guide construction and civil engineering companies to focus on these qualities in order to improve their way of selecting the right CEPM in their projects.

10.5 SUMMARY AND CONCLUSIONS

Quantitative and qualitative approaches were carried out in order to determine the validity of the research findings. Within the first approach (quantitative approach), there were two validation procedures investigated to determine the validity of the derived models. The first validation procedure was the application of the multivariate discriminate analysis (MDA) classification method using the remaining 25 percent hold-out sample data. The 25 percent hold-out sample data was entered in the MDA classification program and results were evaluated for classification accuracy performance. Findings revealed that the classification results provided high consistency and acceptability.

In addition, validation results further revealed similar patterns of performance when compared with the main sample data (75 percent). Therefore, the validation findings of the 25 percent hold-out sample data further reinforced the validity of the derived models.

The second analysis procedure was carried out by utilising a one sample t-test for the remaining 25 percent hold-out sample in which the over-all findings revealed that there was no significant difference between the actual and the predicted group's means values of group classification of good, average and poor CEPM.

A qualitative validation was derived from members of the UK construction industry. A positive feedback from them as confirmed about the findings of this research thus illustrating a high degree of agreement and satisfaction with the results.

With two statistical validation procedures carried out and a qualitative validation approach adopted for deriving industry practitioner's opinions, feedback and comments, these validation methods confirmed that models developed in this study are reliable and robust.

CHAPTER _11_
Conclusions, Recommendations and Further Research

11.0 INTRODUCTION

CEPMs plan, direct and coordinate a wide variety of construction and civil engineering projects, including the building of all types of residential, commercial and industrial structures, roads, bridges, wastewater treatment plants schools, and hospitals. CEPMs may oversee an entire project or just part of a project and, although they usually play no direct role in the actual construction of a structure, they typically schedule and coordinate all design and construction processes, including the selection, hiring, and oversight of specially trade contractor. The first three chapters (literature review) of this thesis established that CEPMs undertake a massive task and have huge responsibility. There is no doubt of the importance of CEPMs in the construction industry. Although there has been a growing recognition of the need for good civil engineering project manager in many construction companies; controversy still exists as to the important criteria that CEPM should have to be classified as a good CEPM.

The final objective of this research was to improve knowledge and provide tools to improve it. The overall role of the CEPM, in this scenario, is to harmonize the functions of planning, communication, monitoring and control the construction project in order to meet this project's overall objectives. This PhD research was focused on classifying the aptitude of CEPM which is one of the main tasks for the construction industry. Employment of CEPMs is expected to increase as fast as the average for all occupations though the year 2009 (Mutch *et al.*, 2002), as the level of construction activity and complexity of construction projects continues to grow. Prospects in construction management, engineering and architectural services and construction contracting firms should be particularly favourable for persons with a degree in construction science which agreed with the general classification models where created in this PhD research.

The aim of this study was to classify the aptitude of civil engineering project manager (CEPM) using MDA technique. The profile developed was then used as the basis for simulation which sough to define and delineate the boundaries of average and poor CEPMs. These three generic classifications then formed the basis of a classification model which used multivariate discriminate analysis (MDA). A comprehensive literature review was undertaken to gather information on existing knowledge related research and therefore consolidate initial thoughts and ideas of the subject area so that an in-depth appreciation of the knowledge domain could be acquired. Key factors identified through the literature that influenced CEPM's aptitude were investigated. Subsequently, it was identified that personal, motivation, education and training, management, work situational, quality project control and planning factors were key factors in differentiating good from bad CEPMs.

The study findings and results were interpreted in the light of data collected from the survey of construction and civil engineering professionals. Bias was minimised when the sample population was targeted to represent the entire United Kingdom construction industry. Having established a robust data population without influence of any bias, the findings were summarised into two sections: i) the profile of CEPM's aptitude, and ii) the classification MDA model.

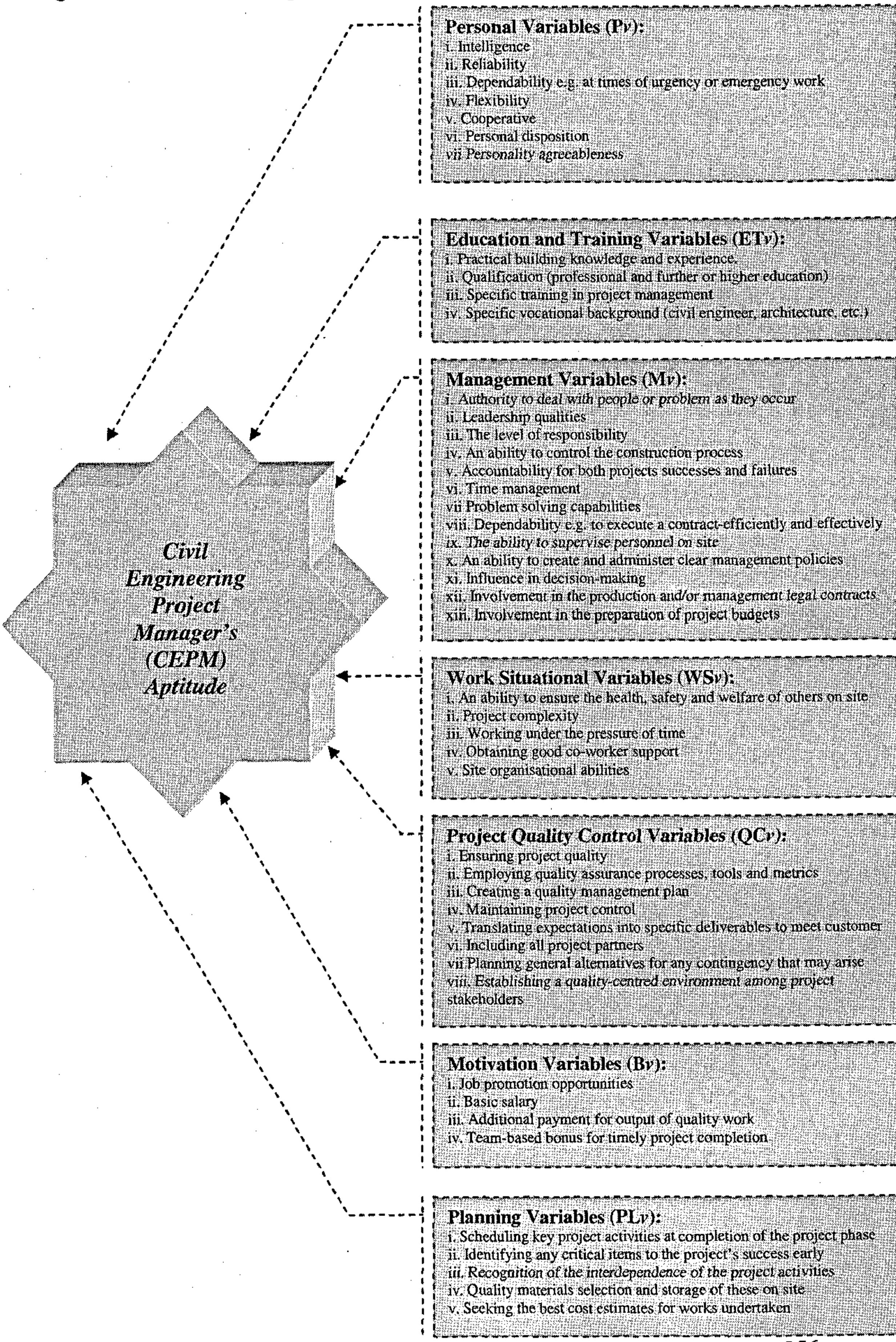
11.1.1 The Profile of Civil Engineering Project Manager's Aptitude (CEPM)

The profile of CEPM's aptitude was derived from a database of 55 independent variables of seven generic factors which covered personal, motivation, education and training, management, work situational, quality project control and planning factors. All of these previously hypothesised variables (55 in total) were shown to have influenced upon the CEPM's aptitude. Nevertheless, survey results revealed that forty-six (46) variables had a significant influence upon the civil engineering project manager's aptitude (Table 11.1 and Fig. 11.1).

Table 11.1 Results Findings: Profile of Civil Engineering Project Manager's (CEPM) Aptitude.

Variable No	Code	Variable (description)	WI	% Weight	Simplified Weight %
01-	Mv2	Authority to deal with people or problem as they occur.	1.00	3.11	3
02-	Mv4	Leadership qualities.....	0.96	2.99	3
03-	Mv1	The level of responsibility	0.95	2.96	3
04-	Mv5	An ability to control the construction process.	0.92	2.86	3
05-	Mv3	Accountability for both projects successes and failures.	0.88	2.74	3
06-	Mv6	Time management	0.82	2.55	3
07-	Pv6	Intelligence.	0.80	2.49	2
08-	Pv5	Reliability.	0.80	2.49	2
09-	Mv7	Problem solving capabilities.	0.80	2.49	2
10-	Pv7	Dependability e.g. at times of urgency or emergency work.	0.80	2.49	2
11-	Mv8	Dependability e.g. to execute a contract-efficiently and effectively.	0.77	2.40	2
12-	Pv9	Flexibility.	0.72	2.24	2
13-	Pv10	Cooperative.	0.72	2.24	2
14-	Mv10	The ability to supervise personnel on site.	0.72	2.24	2
15-	Mv9	An ability to create and administer clear management policies.	0.70	2.18	2
16-	Pv4	Personal disposition.	0.70	2.18	2
17-	Mv12	Influence in decision-making.	0.70	2.18	2
18-	QCv1	Ensuring project quality.	0.70	2.18	2
19-	Pv8	Personality agreeableness.	0.69	2.15	2
20-	WSv5	An ability to ensure the health, safety and welfare of others on site.	0.69	2.15	2
21-	PLv1	Scheduling key project activities at completion of the project phase.	0.66	2.05	2
22-	QCv5	Employing quality assurance processes, tools and metrics.	0.66	2.05	2
23-	PLv3	Identifying any critical items to the project's success early.	0.66	2.05	2
24-	Bv6	Job promotion opportunities.	0.65	2.02	2
25-	ETv3	Practical building knowledge and experience.	0.65	2.02	2
26-	WSv3	Project complexity.	0.65	2.02	2
27-	WSv4	Working under the pressure of time.	0.65	2.02	2
28-	PLv2	Recognition of the interdependence of the project activities.	0.65	2.02	2
29-	QCv3	Creating a quality management plan.	0.64	1.99	2
30-	Mv11	Involvement in the production and/or management legal contracts.	0.64	1.99	2
31-	QCv6	Maintaining project control.	0.63	1.96	2
32-	QCv4	Translating expectations into specific deliverables to meet customer.	0.63	1.96	2
33-	WSv7	Obtaining good co-worker support.	0.63	1.96	2
34-	Bv1	Basic salary.	0.63	1.96	2
35-	Mv13	Involvement in the preparation of project budgets.	0.62	1.93	2
36-	QCv7	Including all project partners.	0.62	1.93	2
37-	Bv3	Additional payment for output of quality work.	0.61	1.90	2
38-	WSv6	Site organisational abilities.	0.60	1.87	2
39-	QCv8	Planning general alternatives for any contingency that may arise.	0.58	1.80	2
40-	QCv2	Establishing a quality-centred environment among project stakeholders.	0.58	1.80	2
41-	PLv5	Quality materials selection and storage of these on site.	0.57	1.77	2
42-	Bv4	Team-based bonus for timely project completion.	0.57	1.77	2
43-	ETv1	Qualification (professional and further or higher education)	0.56	1.74	2
44-	PLv4	Seeking the best cost estimates for works undertaken.	0.56	1.74	2
45-	ETv4	Specific training in project management.	0.55	1.71	2
46-	ETv2	Specific vocational background (civil engineer, architecture, etc.)	0.55	1.71	2

Figure 11.1 Results Findings: The Profile of CEPM's Aptitude.



However, 46 variables clearly presents an overly complex model and would not be favourably received in industry. To overcome this potential difficulty, result findings were further simplified by application of a statistical classification technique using multivariate discriminate analysis (MDA). Exploratory analysis was conducted and simulation procedure was employed to the gathered data.

11.2 The Seven Factors Models (MDA) of CEPM's Aptitude

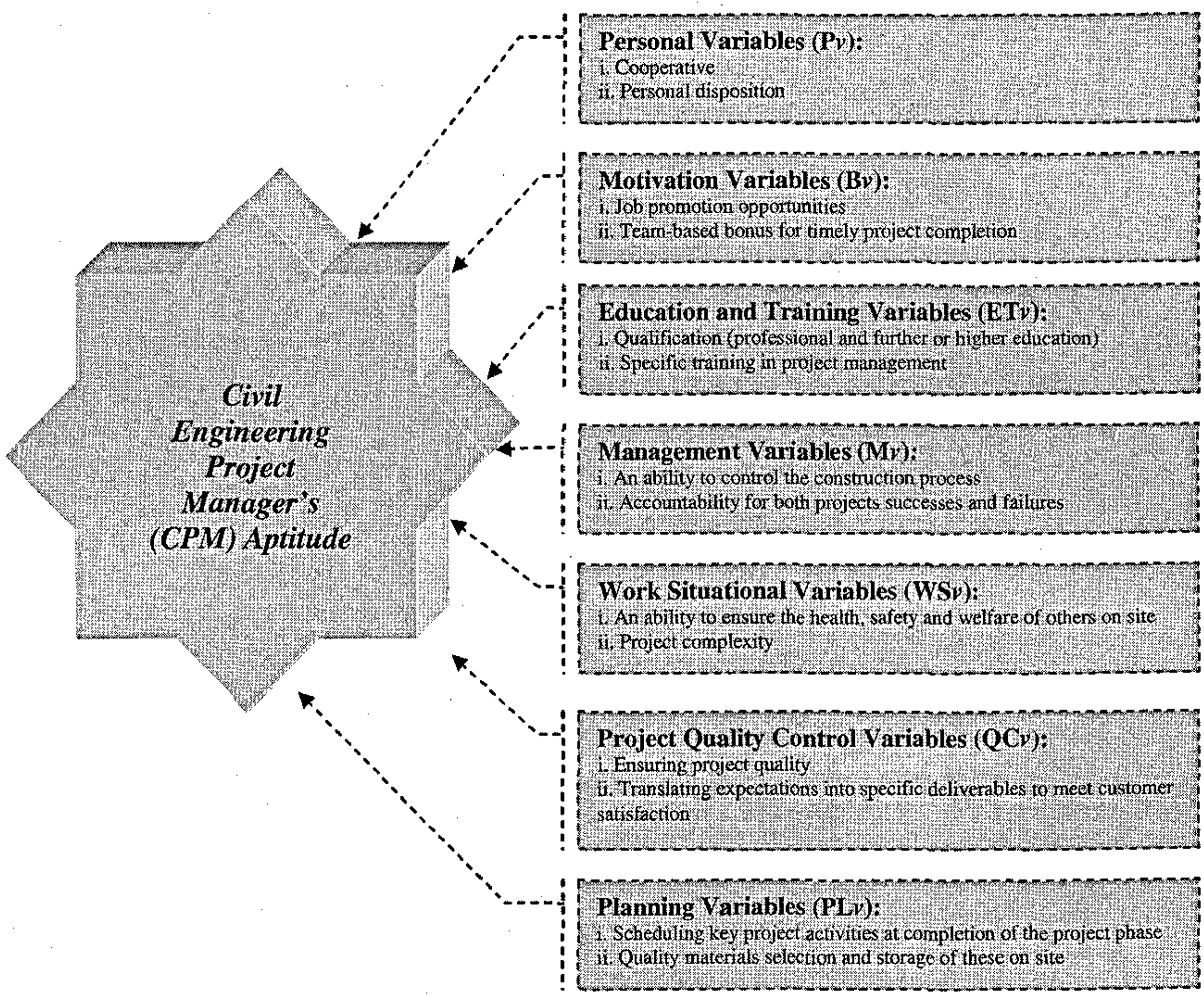
Individual model was derived utilising the findings of the results derived from the individual MDA technique for each of the generic factors (Chapter 9) after all derived variables matched to the CEPM's aptitude profile (Table 11.2). Performance accuracy was determined at 80.7 percent which was validated to provide a high 74.3 percent level of classification accuracy using a 25 percent hold-out sample. Other validation procedures were conducted utilising a one-sample t-test between predicted and actual group classification and the result was no significant difference between the two groups classifications was apparent.

Table 11.2 The Variables of Seven Generic Factors (MDA Model).

Factor	Variable	Description
Personal	P*v*4	Personal Disposition.
Personal	P*v*10	Cooperative e.g. helpful and able to work with others.
Motivation	B*v*4	Team-based bonus for timely project completion.
Motivation	B*v*6	Job promotion opportunities.
Education and Training	ET*v*1	Qualification (PhD, Msc, Bsc, etc.
Education and Training	ET*v*4	Specific training in project management.
Management	M*v*3	Accountability for both projects successes and failure.
Management	M*v*5	An ability to control the construction process.
Work Situation	WS*v*3	Project complexity.
Work Situation	WS*v*5	An ability to ensure the health, safety and welfare of others on site.
Project Quality Control	QC*v*1	Ensuring project quality in order to achieve customer satisfaction.
Project Quality Control	QC*v*4	Translating expectations into specific deliverables to meet customer requirements.
Planning	PL*v*1	Scheduling key project activities at completion of the project design phase.
Planning	PL*v*5	Quality materials selection and storage of these on site.

The study revealed the fourteen (14) of 46 identified independent variables can accurately determine the CEPM's aptitude. All factors were considered. Fig. 11.1-2 presents the diagrammatic findings of the MDA classification results.

Figure 11.2 MDA Result Findings: MDA Classification for Seven Generic Factors.



11.3 The General Models (MDA) of CEPM's Aptitude

A general model was derived utilising the findings of the results derived from the combination of the whole 46 variables in one MDA technique analysis (Chapter 9) after all derived variables matched to the CEPM's aptitude profile and the results derived from the individual MDA technique for each of the generic factors (Table 11.2). Performance accuracy was determined at 80.7 percent which was validated to provide a high 74.3 percent level of classification accuracy using a 25 percent hold-out sample. Other validation procedures were conducted utilising a one-sample t-test between predicted and actual group classification and the result was no significant difference between the two groups classifications was apparent.

Table 11.3 The Variables of General MDA Model.

Factor	Variable	Description
Motivation	Bv4	Team-based bonus for timely project completion.
Education and Training	ETv2	Specific vocational background (civil engineer, architecture engineer, etc).
Education and Training	ETv3	Practical building knowledge and experience.
Work Situation	WSv5	An ability to ensure the health, safety and welfare of others on site.
Planning	PLv2	Recognition of the interdependence of the project activities.

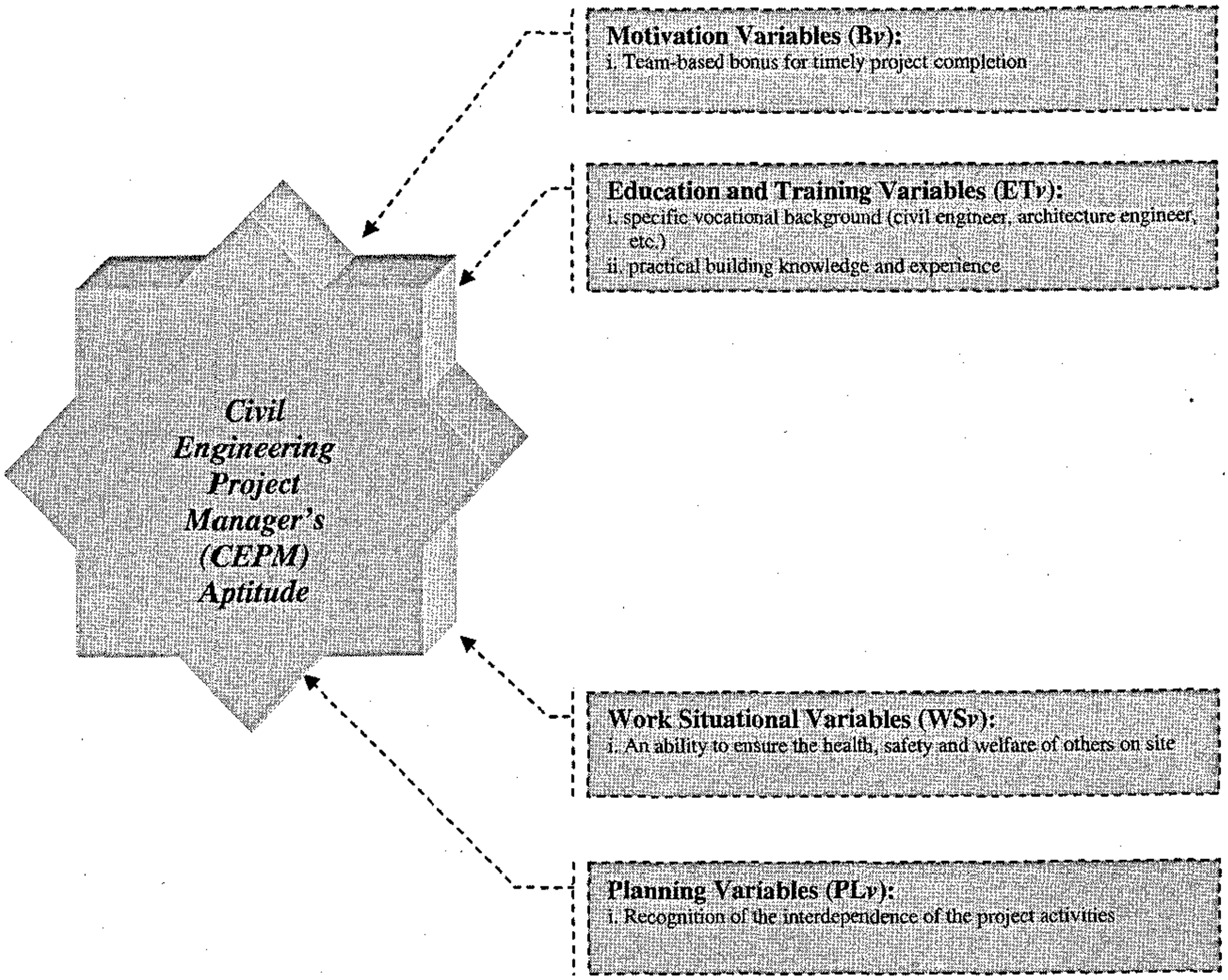
The general MDA model was formulated in the following equation:

$$CEPM's_{(AGM)} = a\ WSv5 + b\ ETv3 + c\ PLv2 + d\ Bv4 + e\ ETv2 + K$$

Where: $CEPM's_{(AGM)}$ is the civil engineering project manager's aptitude, ***a, b, c, d*** and ***e*** are the model co-efficient values and WSv5 (An ability to ensure the health, safety and welfare of others on site); ETv3 (practical building knowledge and experience); PLv2 (recognition of the interdependence of the project activities); Bv4 (Team-based bonus for timely project completion) and ETv2 (specific vocational background).

The study revealed the five variables are: i)Bv4 (Team-based bonus for timely project completion); ETv2 (specific vocational background); ETv3 (practical building knowledge and experience); PLv2 (recognition of the interdependence of the project activities) and WSv5 (An ability to ensure the health, safety and welfare of others on site) of the 46 identified independent variables can accurately determine the CEPM's aptitude. All factors were considered. Fig. 11.1-2 presents the diagrammatic findings of the MDA classification results.

Figure 11.3 General MDA Result Findings: Variables Impact on CEPM's Aptitude.



Because the primary data on which the models developed in this research were obtained from civil engineering project managers, the applicability of the models are most suitable for civil engineering projects. Therefore, caution should be taken in applying the models in other sectors of the construction industry.

11.3 RECOMMENDATIONS AND FUTURE RESEARCH

This research provided this study with ample opportunity to engender further research that needs to be undertaken in order to further construction manager aptitude. The following work can be undertaken in extending and improving the models developed:

- Future work needs to develop a new personal training and selection CD for the models which have been developed in this research. This would allow the fines nuisances of the profile to be used whilst at the same time, providing a user-friendly ICT interface. These would therefore be no need for users to be conversant with complex MDA equations.

- Expansion of knowledge base to incorporate more domain knowledge. As knowledge advances in construction and project management, the models should be upgraded to offer up to date knowledge on the subject.

- Expansion of the models to incorporate different branches of project management i.e. mechanical engineering management. The idea behind models developed should not be restricted to CEPM. Other disciplines within the supply chain could also benefit and these benefits would improve the performance of UK construction.

- An aspect to be further investigated is the depth of learning achieved thorough the use of models developed. This would entail a group to be split with some exposed to the models developed. Comparisons with others would enable quantification of depth of the learning.

- Testing the developed MDA models in this Ph.D research with the classification boundary based on actual project results, e.g. measured by key performance indicates such as time, cost, quality and health and safety.

- Developing a new mathematical model using MDA based upon different criterion (other than experience) to see what the impact upon the model produce within this thesis would be.

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Appendices

Loughborough University

Department of Civil and Building Engineering

Survey Questionnaire: Management of Construction and Civil Engineering Projects

This questionnaire will be used purely for the purposes of academic research. All responses will be treated in strict confidence.

General Instructions: Please **answer all** questions.

- ⊙ Where a box is provided, please **tick** the selection of your choice e.g., ☑
- ⊙ Where a rating scale is provided please **encircle** the number of the scale to indicate your response e.g., 5,④,3, 2,1
- ⊙ Where a line is provided i.e.,________ you can indicate any "other" response you perceive as being appropriate.
- ⊙ Where a ranking column is provided, rank the important items by assigning number 1 as the most important, 2 the next important and so on.
- ⊙ Where a range is provided, please indicate your answer by drawing line under your choice. e.g., [30,000-40,000]

***PART ONE*: PERSONAL DETAILES.**

[1.1] Name of Company ....

[1.2] Company Address:

....

[1.3] Company Telephone Number: .... Company E-mail:

....

[1.4] Your Name:

....

[1.5] How old are you: ❒ 20-29 ❒ 30-39 ❒ 40-49 ❒50 and older.

[1.6] Your Marital Status: ❒ single ❒married other, please specify

....

[1.7] You sex (sex): ❒ Male ❒ Female

[1.8] Your income per annum (UK £ Sterling)

[Up to 30,000] [30,000 - 40,000] [40,000 - 50,000] [50,000- 60,000] [60,000 and over]

[1.9] Years of experience working in the construction industry:

❒ 1-5 years ❒ 5-10 years ❒ 10-15 years ❒15-20 years ❒ 20 years plus.

[1.10] How long have you been employed as a Construction Manager in the present firm;...

[1.11] Your employment status: ❒ directly employed ❒ sub-contractor, other, please specify....................................

[1.11] Please indicate your qualifications: ....

❑ level/GCSE ❑ HNC/HND ❑ Postgraduate (Masters or PhD qualifications.)
❑ A level ❑ Undergraduate (first degree) ❑ Other, please state..

[1.12] Your occupational background

Civil engineering ❑ Construction ❑ Highways ❑ Architecture ❑ Other, please specify ....,

PROJECT SPECIFIC VARIABLES

[1.13] What is the value of the contract you are currently working on? [million, UK £ Sterling] ,

❑ Less than £1m ❑ £1-10m ❑ £10-100m ❑ over £100- please specify ....

[1.14] How long has your company been established? ....years

[1.15] What is the average contract duration for the projects that you work upon:

....

[1.16] Please state the approximate annual turnover for your company (tick one box only):

❑ less than £1m, ❑£1-4m, ❑£5-9m, ❑£10-19m, ❑£20-49m, ❑£50-99m, ❑£100-499m, ❑£500m and over

PART TWO: **Your roles and responsibilities (workplace issues):**

2.1 Does your firm have a formal "*Construction Manager*" title?

❑ Yes ❑ No

2.2 If your answer is yes to the previous question, then does your firm have any formal requirements to be *Construction Manager*?

❑ Yes ❑ No

If so, what are they? *(check all that apply)*

- ❑ Relevant bachelor's degree.
- ❑ Membership of a professional institution.
- ❑ Total years of professional experience (..................... *years*).
- ❑ Completion of in-hours Construction Manager training program (e.g. Continual Professional Development).
- ❑ Other..

2.3 Does your firm have a project management manual (which includes information of issues such as employee training and development, safety etc.) that is provided to all *Construction Managers*?

❑ Yes ❑ No

2.4 Does your firm ever provide its employees with any project management training before they are made Construction Managers?

❑ Always ❑ Sometimes ❑ Rarely ❑ Never

2.5 Does your firm provide any project management training?

❑ Yes, ❑ No

if so, what type(s) of project management training does your firm provide? *(check all that apply)*

❑ on-the-job training ❑ professional courses/school
❑ audio/video tapes ❑ external seminars/conferences
❑ mentoring with senior staff ❑ reading materials

❒ in-house meeting/lectures ❒ other ....

2.6 What firm-specific project management training does your firm provide to its *Construction Managers*? *(check all that apply)*

❒ Preparation of project budgets
❒ Preparation of fee estimates
❒ Preparation of project schedules
❒ Project filing/administration procedures
❒ Planning and scheduling
❒ Contract and relevant legal knowledge
❒ Invoicing procedures
❒ Operational planning
❒ Project close-out procedures
❒ Other
....

2.7 What general skills training does your firm provide to *Construction Managers*? *(check all that apply)*

❒ Management
❒ Communication skills
❒ Collection skills
❒ Leadership (motivation of personnel)
❒ Writing (letters, memos, reports, specifications)
❒ Listening and note-taking
❒ Other ....
❒ Supervision of personnel
❒ Fee negotiation
❒ Dressing appropriately
❒ Client relations
❒ Time management
❒ Oral presentation

2. 8 as a *Construction Manager*, are you responsible for quality assurance/ quality control?

❒ Always ❒ Sometimes ❒ Rarely ❒ Never

PART THREE: ***Civil Engineering Project Managers s Factors***

Please rate and rank the following factors:

Instructions : ✐ ***Encircle*** the number on the scale to indicate the level of agreement of the specific factor, (e.g., 5,④,3, 2,1).

✐ **also** where a ranking column is provided, rank the factors by assigning number 1 as the most important, 2 the next important and so on.

Level of Agreement

	Very important	Sometimes important	Neither important or not important	Often not-important	Never important	Rank
A. Personal Variables: (Pv)	5	4	3	2	1	
B. Motivation Variables: (Bv)	5	4	3	2	1	
C. Education and Training Variables: (ETv)	5	4	3	2	1	
D. Management Variables: (Mv)	5	4	3	2	1	
E. Work Situational Variables: (WSv)	5	4	3	2	1	
F. Project Quality Control Variables: (QCv)	5	4	3	2	1	
G. Planning Variables: (PLv)	5	4	3	2	1	

A. *Personal Variables (Pv)*

With regards to the Construction Manager's ability to manage a contract successfully, please rate and rank the following personal variables.

Level of Agreement

	Very important	Sometimes important	Neither important or not-important	Often not-important	Never important	Rank
Pv1- Age.	5	4	3	2	1	
Pv2- Gender.	5	4	3	2	1	
Pv3- Marital status.	5	4	3	2	1	
Pv4- Personal disposition.	5	4	3	2	1	
Pv5- Reliability e.g. always available when needed.	5	4	3	2	1	
Pv6- Intelligence.	5	4	3	2	1	
Pv7- Dependability e.g. at times of urgency or emergency work.	5	4	3	2	1	
Pv8- Personality agreeableness and openness to new experiences (good personality).	5	4	3	2	1	
Pv9 Flexibility e.g. to undertake a range of tasks and when required.	5	4	3	2	1	
Pv10 Cooperative e.g. helpful and able to work with others.	5	4	3	2	1	
Pv13**Other**, please specify (1):	5	4	3	2	1	

B. *Motivation Variables (Bv)*

With regards to the Construction Manager's ability to manage a contract successfully, please rate and rank the following motivation variables.

Level of Agreement

	Very important	Sometimes important	Neither important or not important	Often not-important	Never important	Rank
Bv1- Basic salary.	5	4	3	2	1	
Bv2- Non financial fringe benefits and incentives such as educational opportunities.	5	4	3	2	1	
Bv3- Additional "bonus" payment for output of quality work.	5	4	3	2	1	
Bv4- Team-based bonus for timely project completion.	5	4	3	2	1	
Bv5- Additional payment for completing the project on time or early.	5	4	3	2	1	
Bv6- Job promotion opportunities.	5	4	3	2	1	
Bv8- **Other**, specify (1):	5	4	3	2	1	

C. *Education and Training Variables (ETv):*

With regards to the Civil Engineering Project Manager's ability to manage a contract successfully, please rate and rank the following education and training variables.

Level of Agreement

	Very important	Sometimes important	Neither important or not-important	Often not-important	Never important	Rank
ETv1- Qualification (professional and further or higher education e.g. PhD, Ms.c, Bs.c, etc).	5	4	3	2	1	
ETv2- Specific vocational background (civil engineer, architecture engineer, etc).	5	4	3	2	1	
ETv3- Practical building knowledge and experience.	5	4	3	2	1	
ETv4- Specific training in project management.	5	4	3	2	1	

ETv5- Continual professional training certificates and/or attendance at relevant events.	5	4	3	2	1	
ETv6- **Other**, specify (1):	5	4	3	2	1	

D. *Management Variables (Mv):*

With regards to the Civil Engineering Project Manager's ability to manage a contract successfully, please rate and rank the following management variables.

	Level of Agreement					
	Very important	Sometimes important	Neither important or not-important	Often not-important	Never important	Rank
Mv1- The level of responsibility and autonomy given, to act as appropriate when action is required.	5	4	3	2	1	
Mv2- Authority to deal with people or problems as they occur.	5	4	3	2	1	
Mv3- Accountability for both projects' successes and failures.	5	4	3	2	1	
Mv4- Leadership qualities to encourage personnel to be effective and efficient.	5	4	3	2	1	
Mv5- An ability to control the construction process.	5	4	3	2	1	
Mv6- Time management.	5	4	3	2	1	
Mv7- Problem solving capabilities.	5	4	3	2	1	
Mv8- Dependability e.g. to execute a contract-efficiently and effectively.	5	4	3	2	1	
Mv9- An ability to create and administer clear management policies.	5	4	3	2	1	
Mv10- The ability to supervise personnel on site.	5	4	3	2	1	
Mv11- Involvement in the production and /or management legal contracts.	5	4	3	2	1	
Mv12- Influence in decision-making	5	4	3	2	1	
Mv13- Involvement in the preparation of project budgets.	5	4	3	2	1	

Mv15- **Other**, specify (1):	5	4	3	2	1	

E. *Work Situational Variables (WSv):*

With regards to the Civil Engineering Project Manager's ability to manage a contract successfully, please rate and rank the following work situational variables.

	Level of Agreement					
	Very important	Sometimes important	Neither important or not- important	Often not- important	Never important	Rank
WSv1- Working in extreme weather.	5	4	3	2	1	
WSv2- Site conditions (e.g., access and egress to work, available facilities and amenities etc.)	5	4	3	2	1	
WSv3- Project complexity.	5	4	3	2	1	
WSv4- Working under the pressure of time particularly when contracts are behind schedule.	5	4	3	2	1	
WSv5- An ability to ensure the health, safety and welfare of others on site.	5	4	3	2	1	
WSv6- Site organizational abilities e.g. good clear site transport/pedestrian routes, storage areas etc.	5	4	3	2	1	
WSv7- Obtaining good co-worker support.	5	4	3	2	1	
WSv8- **Other**, specify (1):	5	4	3	2	1	

F. *Project Quality Control Variables(QCv):*

With regards to the Construction Manager's ability to manage a contract successfully, please rate and rank the following quality control variables.

	Level of Agreement					
	Very important	Sometimes important	Neither important or not- important	Often not- important	Never important	Rank
QCv1- Ensuring project quality in order to achieve customer satisfaction.	5	4	3	2	1	
QCv2- Establishing a quality-centred environment among project	5	4	3	2	1	

stakeholders						
QCv3- Creating a quality management plan to deliver promised value.	5	4	3	2	1	
QCv4- Translating expectations into specific deliverables to meet customer requirements	5	4	3	2	1	
QCv5- Employing quality assurance processes, tools and metrics.	5	4	3	2	1	
QCv6- Maintaining project control, correcting deviations and avoiding defect reoccurrence.	5	4	3	2	1	
QCv7- Including all project partners (e.g. sub contractors) in the monitoring of quality process.	5	4	3	2	1	
QCv8- Planning general alternatives for any contingency that may arise.	5	4	3	2	1	
QCv9- **Other**, specify (1):	5	4	3	2	1	

G. *Planning factors(PLv):*

With regards to the Construction Manager's ability to manage a contract successfully, please rate and rank the following planning variables.

Level of Agreement

	Very important	Sometimes important	Neither important or not-important	Often not-important	Never important	Rank
PLv1- Scheduling key project activities at completion of the project design phase.	5	4	3	2	1	
PLv2- Recognition of the interdependence of the project activities.	5	4	3	2	1	
PLv3- Identifying any critical items to the project's success early e.g. sub-contractor capability.	5	4	3	2	1	
PLv4- Seeking the best cost estimates for works undertaken.	5	4	3	2	1	
PLv5- Modifying and updating the schedule of works in line with any changes made.	5	4	3	2	1	
PLv6- Quality materials selection and storage of these on site.	5	4	3	2	1	
PLv7- Selection of appropriate plant and equipment.	5	4	3	2	1	
PLv9- **Other**, specify (1):	5	4	3	2	1	

Are there future comments you wish to make about the construction and civil engineering project managers? If yes, please write your comment (s) below.

Please return your completed questionnaire in the stamped addressed envelope provided to:

✉
Z. M. Othman, Bs.c (Civil Eng.), MPhil (Structural Eng.).
Currently Doctoral Researcher
Civil and Building Engineering Department,
Loughborough University,
Leicestershire, LE11 3TU,UK.
E-mail: Z.M.Othman@lboro.ac.uk
☎ Tel: + 44 (0)1509 263171; ☎ Extension No: 4140
Fax: + 44 (0)1509 223981

Thank you for completing this questionnaire. Copies of the research findings will be made available upon request to the author detailed above.

Loughborough University

Department Of Civil and Building Engineering

Date:

____

____

____

____

____

Dear Project Manager, (Civil Engineering Projects)

SUBJECT: SURVEY QUESTIONNAIRE FOR CLASSIFY THE APTITUDE OF THE CONSTRUCTION AND THE CIVIL ENGINEERING PROJECT MANAGERS.

At Loughborough University the one of its own research group has presently involving and carrying out research into improving construction & civil engineering project manager's performance in the UK.

Subsequently, the aim of this research is to classify the aptitude (ability) of the construction & and civil engineering project managers in the United Kingdom. In order to achieve this aim, you as civil engineering project managers are required kindly to complete the attached questionnaire. Your responses will be used to construct a mathematical model of key manager performance variables.

All information provided by you will be treated with strict confidence. Further, as a respondent to the survey you will be able to obtain a free copy of the research finding once complete.

Please return the completed questionnaire as soon as possible using the stamped/addressed envelope provided.

Should you require any future information, please do not hesitate to contact me.

Thank you for your co-operation. I shall look forward to receiving the completed questionnaire.

Your faithfully,

Z. M, Othman
Bs.c (Civil Eng.), MPhil (Structural Eng.).
Currently Doctoral Researcher
Civil and Building Engineering Department,
Loughborough University,
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APPENDIX D. Civil Engineering Project Manager's (CEPM's) Profile Sheet

1	Authority to deal with people or problem as they occur.	Maximum Score 3 %
1.1	Good	3 ☐
1.2	Fair	2 ☐
1.3	Poor	1 ☐
Total		3 %

2	Leadership qualities to encourage personnel to be effective and efficient.	Maximum Score 3 %
2.1	Good	3 ☐
2.2	Fair	2 ☐
2.3	Poor	1 ☐
Total		3 %

3	The level of responsibility and autonomy given, to act as appropriate when action is required.	Maximum Score 3 %
3.1	Good	3 ☐
3.2	Fair	2 ☐
3.3	Poor	1 ☐
Total		3 %

4	An ability to control the construction process.	Maximum Score 3 %
4.1	Good	3 ☐
4.2	Fair	2 ☐
4.3	Poor	1 ☐
Total		3 %

5	Accountability for both projects' successes and failures.	Maximum Score 3 %
5.1	Good	3 ☐
5.2	Fair	2 ☐
5.3	Poor	1 ☐
Total		3 %

6	Time management.	Maximum Score 3 %
6.1	Good	3 ☐
6.2	Fair	2 ☐
6.3	Poor	1 ☐
Total		3 %

7	Intelligence.	Maximum Score 3 %
7.1	High	2 ☐
7.2	Low	1 ☐
Total		2 %

8	Reliability e.g. always available when needed.	Maximum Score 3 %
8.1	High	2 ☐
8.2	Low	1 ☐
Total		2 %

9	Problem solving capabilities	Maximum Score 3 %
9.1	High	2 ☐
9.2	Low	1 ☐
Total		2 %

10	Dependability e.g. at times of urgency or emergency work.	Maximum Score 3 %
10.1	High	2 ☐
10.2	Low	1 ☐
Total		2 %

11	Dependability e.g. to execute a contract efficiently and effectively.	Maximum Score 3 %
11.1	High	2 ☐
11.2	Low	1 ☐
Total		2 %

12	Flexibility e.g. to undertake a range of tasks and when required.	Maximum Score 3 %
12.1	High	2 ☐
12.2	Low	1 ☐
Total		2 %

13	Cooperative e.g. helpful and able to work with others.	Maximum Score 3 %
13.1	Good	2 ☐
13.2	Fair	1 ☐
Total		2 %

14	The ability to supervise personnel on site	Maximum Score 3 %
14.1	High	2 ☐
14.2	Low	1 ☐
Total		2 %

15	An ability to create and administer clear management policies.	Maximum Score 3 %
15.1	High	2 □
15.2	Low	1 □
Total		2 %

16	Personal disposition.	Maximum Score 3 %
16.1	High	2 □
16.2	Low	1 □
Total		2 %

17	Influence in decision-making.	Maximum Score 3 %
17.1	High	2 □
17.2	Low	1 □
Total		2 %

18	Ensuring project quality.	Maximum Score 3 %
18.1	High	2 □
18.2	Low	1 □
Total		2 %

19	Personality agreeableness and openness to new experiences.	Maximum Score 3 %
19.1	High	2 □
19.2	Low	1 □
Total		2 %

20	An ability to ensure the health, safety and welfare of others on site.	Maximum Score 3 %
20.1	High	2 □
20.2	Low	1 □
Total		2 %

21	Scheduling key project activities at completion of the project design phase.	Maximum Score 3 %
21.1	High	2 □
21.2	Low	1 □
Total		2 %

22	Employing quality assurance processes, tools and metrics.	Maximum Score 3 %
22.1	Yes	2 □
22.2	No	1 □
Total		2 %

23	Identifying any critical items to the project's success early e.g. sub-contractor capability.	Maximum Score 3 %
23.1	High	2 □
23.2	Low	1 □
Total		2 %

24	Job promotion opportunities.	Maximum Score 3 %
24.1	Yes	2 □
24.2	No	1 □
Total		2 %

25	Practical building knowledge and experience.	Maximum Score 3 %
25.1	High	2 □
25.2	Low	1 □
Total		2 %

26	Project complexity.	Maximum Score 3 %
26.1	High	2 □
26.2	Low	1 □
Total		2 %

27	Working under the pressure of time particularly when contracts are behind schedule.	Maximum Score 3 %
27.1	Yes	2 □
27.2	No	1 □
Total		2 %

28	Recognition of the interdependence of the project activities.	Maximum Score 3 %
28.1	High	2 □
28.2	Low	1 □
Total		2 %

29	Creating a quality management plan to deliver promised value.	Maximum Score 3 %
29.1	High	2 □
29.2	Low	1 □
Total		2 %

30	Involvement in the production and /or management legal contracts.	Maximum Score 3 %
30.1	Yes	2 □
30.2	No	1 □
Total		2 %

31	Maintaining project control, correcting deviations and avoiding defect reoccurrence.	Maximum Score 3 %
31.1	Yes	2 □
31.2	No	1 □
Total		2 %

32	Translating expectations into specific deliverables to meet customer requirements	Maximum Score 3 %
31.1	High	2 □
32.2	Low	1 □
Total		2 %

33	Obtaining good co-worker support.	Maximum Score 3 %
33.1	High	2 □
33.2	Low	1 □
Total		2 %

34	Basic salary.	Maximum Score 3 %
34.1	Good	2 □
34.2	Fair	1 □
Total		2 %

35	Involvement in the preparation of project budgets.	Maximum Score 3 %
35.1	Yes	2 □
35.2	No	1 □
Total		2 %

36	Including all project partners (e.g. sub contractors) in the monitoring of quality process.	Maximum Score 3 %
36.1	High	2 □
36.2	Low	1 □
Total		2 %

37	Additional "bonus" payment for output of quality work.	Maximum Score 3 %
37.1	Yes	2 □
37.2	No	1 □
Total		2 %

38	Site organizational abilities e.g. good clear site transport/pedestrian routes, storage areas etc.	Maximum Score 3 %
38.1	High	2 □
38.2	Low	1 □
Total		2 %

39	Planning general alternatives for any contingency that may arise.	Maximum Score 3 %
39.1	Yes	2 □
39.2	No	1 □
Total		2 %

40	Establishing a quality-centred environment among project stakeholders	Maximum Score 3 %
40.1	High	2 □
40.2	Low	1 □
Total		2 %

41	Quality materials selection and storage of these on site.	Maximum Score 3 %
41.1	High	2 □
41.2	Low	1 □
Total		2 %

42	Team-based bonus for timely project completion.	Maximum Score 3 %
32.1	Yes	2 □
32.2	No	1 □
Total		2 %

43	Qualification (professional and further or higher education e.g. PhD, Ms.c, Bs.c, etc).	Maximum Score 3 %
43.1	High	2 □
43.2	Low	1 □
Total		2 %

44	Seeking the best cost estimates for works undertaken.	Maximum Score 3 %
44.1	Yes	2 □
44.2	No	1 □
Total		2 %

45	Specific training in project management.	Maximum Score 3 %
45.1	Yes	2 □
45.2	No	1 □
Total		2 %

46	Specific vocational background (civil engineer, architecture engineer, etc).	Maximum Score 3 %
46.1	Yes	2 □
46.2	No	1 □
Total		2 %

Total score: (summation of all scores obtained from questions 1-46) = ___%

Civil Engineering Project Managers Classification:

Good CEPM: 80.4-100 %

Average CEPM: 19.8-80.3 %

Poor CEPM: 0-19.7 %

Eigenvalues

Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	1.283(a)	60.1	60.1	.750
2	.851(a)	39.9	100.0	.678

a First 2 canonical discriminate functions were used in the analysis.

Wilks' Lambda

Test of Function(s)	Wilks' Lambda	Chi-square	df	Sig.
1 through 2	.237	59.097	10	.000
2	.540	25.250	4	.000

Standardized Canonical Discriminate Function Coefficients

	Function	
	1	2
Team-based Bonus for Timely Project Completion	.065	1.040
Specific Vocational Background (civil engineer, architecture engineer, etc)	-.892	-.184
Practical Building knowledge and Experience	.642	.394
An Ability to Ensure the Health, Safety and Welfare of others on site	.187	-.850
Recognition of the Interdependence of the Project Activities	.416	.735

Canonical Discriminate Function Coefficients

	Function	
	1	2
Team-based Bonus for Timely Project Completion	.100	1.605
Specific Vocational Background (civil engineer, architecture engineer, etc)	-1.407	-.290
Practical Building knowledge and Experience	1.289	.790
An Ability to Ensure the Health, Safety and Welfare of others on site	.310	-1.409
Recognition of the Interdependence of the Project Activities	.554	.979
(Constant)	-4.012	-6.737

Unstandardized coefficients

Functions at Group Centroids

	Function	
Group of the CM	1	2
Poor	.785	.622
Average	-1.499	-.024
Good	.849	-1.989

Unstandardized canonical discriminate functions evaluated at group means

Classification Processing Summary

Processed		68
Excluded	Missing or out-of-range group codes	0
	At least one missing discriminating variable	0
Used in Output		68

Prior Probabilities for Groups

		Cases Used in Analysis	
Group of the CM	Prior	Unweighted	Weighted
Poor	.333	23	23.000
Average	.333	16	16.000
Good	.333	7	7.000
Total	1.000	46	46.000

Classification Function Coefficients

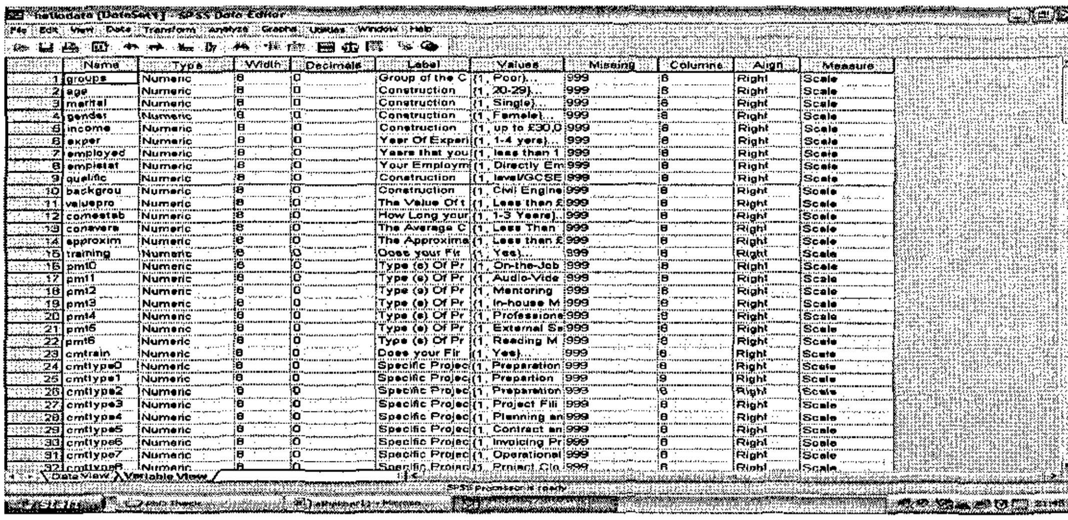
	Group of the CM		
	Poor	Average	Good
Team-based Bonus for Timely Project Completion	10.842	9.576	6.657
Specific Vocational Background (civil engineer, architecture engineer, etc)	4.416	7.816	5.082
Practical Building knowledge and Experience	22.258	18.803	20.277
An Ability to Ensure the Health, Safety and Welfare of others on site	5.029	5.231	8.728
Recognition of the Interdependence of the Project Activities	12.218	10.319	9.697
(Constant)	-123.416	-110.519	-107.917

Fisher's linear discriminate functions

Classification Results(a,b)

			Group of the CM	Predicted Group Membership			Total
				Poor	Average	Good	
Cases Selected	Original	Count	Poor	19	2	2	23
			Average	2	14	0	16
			Good	1	0	6	7
		%	Poor	82.6	8.7	8.7	100.0
			Average	12.5	87.5	.0	100.0
			Good	14.3	.0	85.7	100.0
Cases Not Selected	Original	Count	Poor	6	4	0	10
			Average	3	9	0	12
			Good	0	0	0	0
		%	Poor	73.3	40.0	.0	100.0
			Average	25.0	75.0	.0	100.0
			Good	.0	.0	82.3	100.0

a 84.8% of selected original grouped cases correctly classified.
b 76.2% of unselected original grouped cases correctly classified.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
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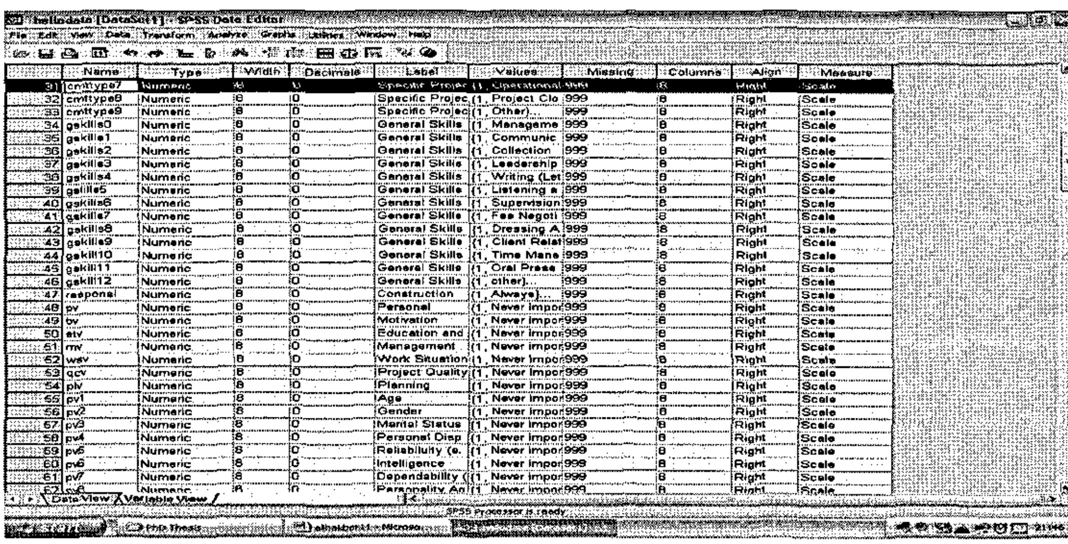
2	age	Numeric	8	0	Construction	{1, 20-29)...	999	8	Right	Scale
3	marital	Numeric	8	0	Construction	{1, Single)...	999	8	Right	Scale
4	gender	Numeric	8	0	Construction	{1, Female)...	999	8	Right	Scale
5	income	Numeric	8	0	Construction	{1, up to £30,0	999	8	Right	Scale
6	exper	Numeric	8	0	Year Of Experi	{1, 1-4 years)...	999	8	Right	Scale
7	employed	Numeric	8	0	Years that you	{1, less than 1	999	8	Right	Scale
8	emplstat	Numeric	8	0	Your Employm	{1, Directly Em	999	8	Right	Scale
9	qualific	Numeric	8	0	Construction	{1, level/GCSE	999	8	Right	Scale
10	backgrou	Numeric	8	0	Construction	{1, Civil Engine	999	8	Right	Scale
11	valuepro	Numeric	8	0	The Value Of t	{1, Less than £	999	8	Right	Scale
12	comestab	Numeric	8	0	How Long your	{1, 1-3 Years)...	999	8	Right	Scale
13	conevera	Numeric	8	0	The Average C	{1, Less Than	999	8	Right	Scale
14	approxim	Numeric	8	0	The Approxima	{1, Less than £	999	8	Right	Scale
15	training	Numeric	8	0	Does your Fir	{1, Yes)...	999	8	Right	Scale
16	pmt0	Numeric	8	0	Type (s) Of Pr	{1, On-the-Job	999	8	Right	Scale
17	pmt1	Numeric	8	0	Type (s) Of Pr	{1, Audio-Vide	999	8	Right	Scale
18	pmt2	Numeric	8	0	Type (s) Of Pr	{1, Mentoring	999	8	Right	Scale
19	pmt3	Numeric	8	0	Type (s) Of Pr	{1, In-house M	999	8	Right	Scale
20	pmt4	Numeric	8	0	Type (s) Of Pr	{1, Professione	999	8	Right	Scale
21	pmt5	Numeric	8	0	Type (s) Of Pr	{1, External Se	999	8	Right	Scale
22	pmt6	Numeric	8	0	Type (s) Of Pr	{1, Reading M	999	8	Right	Scale
23	cmtrain	Numeric	8	0	Does your Fir	{1, Yes)...	999	8	Right	Scale
24	cmttype0	Numeric	8	0	Specific Projec	{1, Preparation	999	8	Right	Scale
25	cmttype1	Numeric	8	0	Specific Projec	{1, Preparation	999	8	Right	Scale
26	cmttype2	Numeric	8	0	Specific Projec	{1, Preparation	999	8	Right	Scale
27	cmttype3	Numeric	8	0	Specific Projec	{1, Project Fill	999	8	Right	Scale
28	cmttype4	Numeric	8	0	Specific Projec	{1, Planning an	999	8	Right	Scale
29	cmttype5	Numeric	8	0	Specific Projec	{1, Contract an	999	8	Right	Scale
30	cmttype6	Numeric	8	0	Specific Projec	{1, Invoicing Pr	999	8	Right	Scale
31	cmttype7	Numeric	8	0	Specific Projec	{1, Operational	999	8	Right	Scale
32	cmttype8	Numeric	8	0	Specific Projec	{1, Project Clo	999	8	Right	Scale



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
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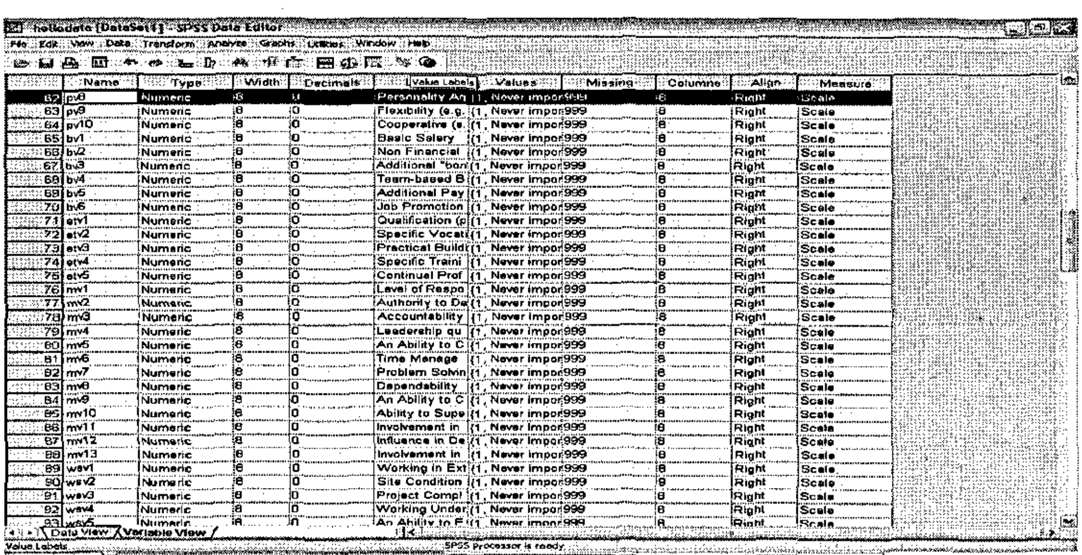
33	cmttype9	Numeric	8	0	Specific Projec	{1, Other)...	999	8	Right	Scale
34	gskills0	Numeric	8	0	General Skills	{1, Manageme	999	8	Right	Scale
35	gskills1	Numeric	8	0	General Skills	{1, Communic	999	8	Right	Scale
36	gskills2	Numeric	8	0	General Skills	{1, Collection	999	8	Right	Scale
37	gskills3	Numeric	8	0	General Skills	{1, Leadership	999	8	Right	Scale
38	gskills4	Numeric	8	0	General Skills	{1, Writing (Let	999	8	Right	Scale
39	gskills5	Numeric	8	0	General Skills	{1, Listening a	999	8	Right	Scale
40	gskills6	Numeric	8	0	General Skills	{1, Supervision	999	8	Right	Scale
41	gskills7	Numeric	8	0	General Skills	{1, Fee Negoti	999	8	Right	Scale
42	gskills8	Numeric	8	0	General Skills	{1, Dressing A	999	8	Right	Scale
43	gskills9	Numeric	8	0	General Skills	{1, Client Relat	999	8	Right	Scale
44	gskill10	Numeric	8	0	General Skills	{1, Time Mana	999	8	Right	Scale
45	gskill11	Numeric	8	0	General Skills	{1, Oral Prese	999	8	Right	Scale
46	gskill12	Numeric	8	0	General Skills	{1, other)...	999	8	Right	Scale
47	responsl	Numeric	8	0	Construction	{1, Always)...	999	8	Right	Scale
48	pv	Numeric	8	0	Personal	{1, Never impor	999	8	Right	Scale
49	bv	Numeric	8	0	Motivation	{1, Never impor	999	8	Right	Scale
50	etv	Numeric	8	0	Education and	{1, Never impor	999	8	Right	Scale
51	mv	Numeric	8	0	Management	{1, Never impor	999	8	Right	Scale
52	wsv	Numeric	8	0	Work Situation	{1, Never impor	999	8	Right	Scale
53	qcv	Numeric	8	0	Project Quality	{1, Never impor	999	8	Right	Scale
54	plv	Numeric	8	0	Planning	{1, Never impor	999	8	Right	Scale
55	pv1	Numeric	8	0	Age	{1, Never impor	999	8	Right	Scale
56	pv2	Numeric	8	0	Gender	{1, Never impor	999	8	Right	Scale
57	pv3	Numeric	8	0	Marital Status	{1, Never impor	999	8	Right	Scale
58	pv4	Numeric	8	0	Personal Disp	{1, Never impor	999	8	Right	Scale
59	pv5	Numeric	8	0	Reliability (e.	{1, Never impor	999	8	Right	Scale
60	pv6	Numeric	8	0	Intelligence	{1, Never impor	999	8	Right	Scale
61	pv7	Numeric	8	0	Dependability (	{1, Never impor	999	8	Right	Scale
62	pv8	Numeric	8	0	Personality An	{1, Never impor	999	8	Right	Scale



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
62	pv8	Numeric	8	0	Personality An	{1, Never impor	999	8	Right	Scale
63	pv9	Numeric	8	0	Flexibility (e.g.	{1, Never impor	999	8	Right	Scale
64	pv10	Numeric	8	0	Cooperative (e.	{1, Never impor	999	8	Right	Scale
65	bv1	Numeric	8	0	Basic Salary	{1, Never impor	999	8	Right	Scale
66	bv2	Numeric	8	0	Non Financial	{1, Never impor	999	8	Right	Scale
67	bv3	Numeric	8	0	Additional "bon	{1, Never impor	999	8	Right	Scale
68	bv4	Numeric	8	0	Team-based B	{1, Never impor	999	8	Right	Scale
69	bv5	Numeric	8	0	Additional Pay	{1, Never impor	999	8	Right	Scale
70	bv6	Numeric	8	0	Job Promotion	{1, Never impor	999	8	Right	Scale
71	etv1	Numeric	8	0	Qualification (p	{1, Never impor	999	8	Right	Scale
72	etv2	Numeric	8	0	Specific Vocati	{1, Never impor	999	8	Right	Scale
73	etv3	Numeric	8	0	Practical Build	{1, Never impor	999	8	Right	Scale
74	etv4	Numeric	8	0	Specific Traini	{1, Never impor	999	8	Right	Scale
75	etv5	Numeric	8	0	Continual Prof	{1, Never impor	999	8	Right	Scale
76	mv1	Numeric	8	0	Level of Respo	{1, Never impor	999	8	Right	Scale
77	mv2	Numeric	8	0	Authority to De	{1, Never impor	999	8	Right	Scale
78	mv3	Numeric	8	0	Accountability	{1, Never impor	999	8	Right	Scale
79	mv4	Numeric	8	0	Leadership qu	{1, Never impor	999	8	Right	Scale
80	mv5	Numeric	8	0	An Ability to C	{1, Never impor	999	8	Right	Scale
81	mv6	Numeric	8	0	Time Manage	{1, Never impor	999	8	Right	Scale
82	mv7	Numeric	8	0	Problem Solvin	{1, Never impor	999	8	Right	Scale
83	mv8	Numeric	8	0	Dependability	{1, Never impor	999	8	Right	Scale
84	mv9	Numeric	8	0	An Ability to C	{1, Never impor	999	8	Right	Scale
85	mv10	Numeric	8	0	Ability to Supe	{1, Never impor	999	8	Right	Scale
86	mv11	Numeric	8	0	Involvement in	{1, Never impor	999	8	Right	Scale
87	mv12	Numeric	8	0	Influence in De	{1, Never impor	999	8	Right	Scale
88	mv13	Numeric	8	0	Involvement in	{1, Never impor	999	8	Right	Scale
89	wsv1	Numeric	8	0	Working in Ext	{1, Never impor	999	8	Right	Scale
90	wsv2	Numeric	8	0	Site Condition	{1, Never impor	999	8	Right	Scale
91	wsv3	Numeric	8	0	Project Compl	{1, Never impor	999	8	Right	Scale
92	wsv4	Numeric	8	0	Working Under	{1, Never impor	999	8	Right	Scale
93	wsv5	Numeric	8	0	An Ability to F	{1, Never impor	999	8	Right	Scale

hellodata [DataSet1] - SPSS Data Editor

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
93	wsv5	Numeric	8	0	An Ability to E	{1, Never impor	999	8	Right	Scale
94	wsv6	Numeric	8	0	Site Organizati	{1, Never impor	999	8	Right	Scale
95	wsv7	Numeric	8	0	Obtaining Goo	{1, Never impor	999	8	Right	Scale
96	qcv1	Numeric	8	0	Ensuring Proje	{1, Never impor	999	8	Right	Scale
97	qcv2	Numeric	8	0	Establishing a	{1, Never impor	999	8	Right	Scale
98	qcv3	Numeric	8	0	Creating a Qua	{1, Never impor	999	8	Right	Scale
99	qcv4	Numeric	8	0	Translating Ex	{1, Never impor	999	8	Right	Scale
100	qcv5	Numeric	8	0	Employing Qu	{1, Never impor	999	8	Right	Scale
101	qcv6	Numeric	8	0	Maintaining Pr	{1, Never impor	999	8	Right	Scale
102	qcv7	Numeric	8	0	Including all Pr	{1, Never impor	999	8	Right	Scale
103	qcv8	Numeric	8	0	Planning Gene	{1, Never impor	999	8	Right	Scale
104	plv1	Numeric	8	0	Scheduling Ke	{1, Never impor	999	8	Right	Scale
105	plv2	Numeric	8	0	Recognition of	{1, Never impor	999	8	Right	Scale
106	plv3	Numeric	8	0	Identify any cri	{1, Never impor	999	8	Right	Scale
107	plv4	Numeric	8	0	Seeking the B	{1, Never impor	999	8	Right	Scale
108	plv5	Numeric	8	0	Quality Materi	{1, Never impor	999	8	Right	Scale
109	plv6	Numeric	8	0	Selection of A	{1, Never impor	999	8	Right	Scale
110	rpv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
111	rbv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
112	retv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
113	rmv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
114	rwsv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
115	rqcv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
116	rplv	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
117	rpv1	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
118	rpv2	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
119	rpv3	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
120	rpv4	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
121	rpv5	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
122	rpv6	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
123	rpv7	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
124	rpv8	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale

Data View / Variable View — SPSS Processor is ready

hellodata [DataSet1] - SPSS Data Editor

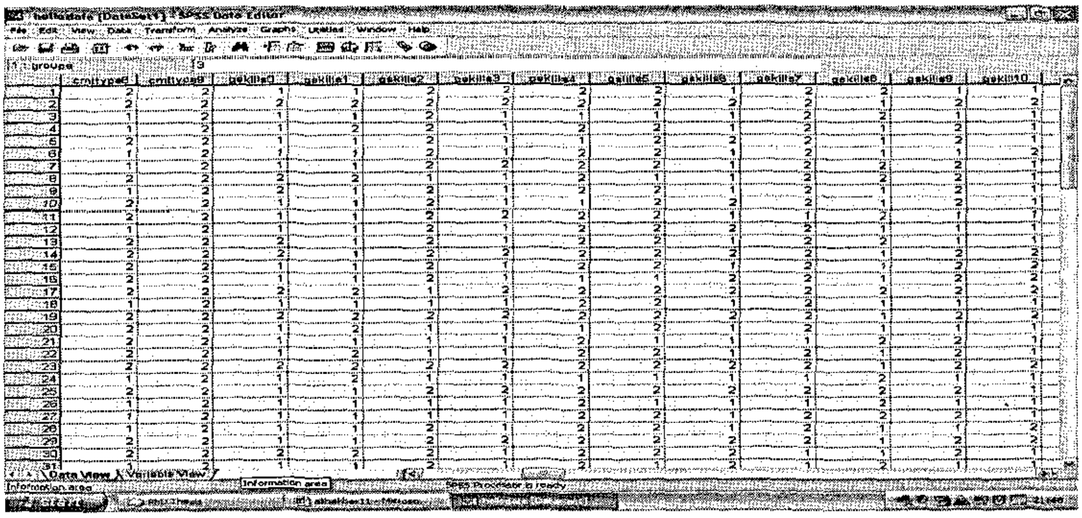
	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
124	rpv8	Numeric	8	0	Rank Rating of	{1, 1}	999	8	Right	Scale
125	rpv9	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
126	rpv10	Numeric	8	0	Rank Rating of	{1, 1}...	999	8	Right	Scale
127	rbv1	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
128	rbv2	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
129	rbv3	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
130	rbv4	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
131	rbv5	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
132	rbv6	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
133	retv1	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
134	retv2	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
135	retv3	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
136	retv4	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
137	retv5	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
138	rmv1	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
139	rmv2	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
140	rmv3	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
141	rmv4	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
142	rmv5	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
143	rmv6	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
144	rmv7	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
145	rmv8	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
146	rmv9	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
147	rmv10	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
148	rmv11	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
149	rmv12	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
150	rmv13	Numeric	8	0	Rank Rating of	{1, 1.3}...	999	8	Right	Scale
151	rwsv1	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
152	rwsv2	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
153	rwsv3	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
154	rwsv4	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
155	rwsv5	Numeric	8	0	Rank Rating of	{1, 0.7}	999	8	Right	Scale

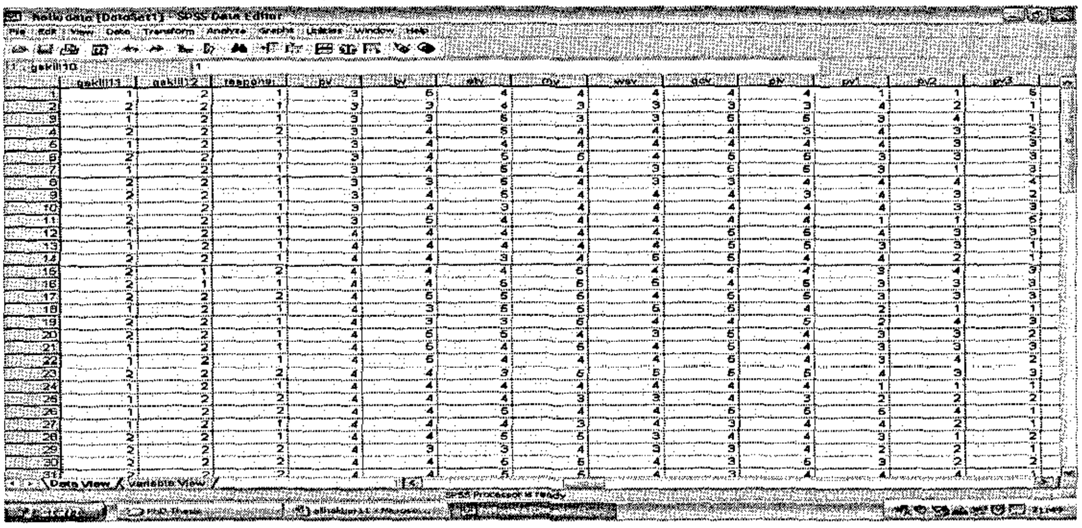
Data View / Variable View — SPSS Processor is ready

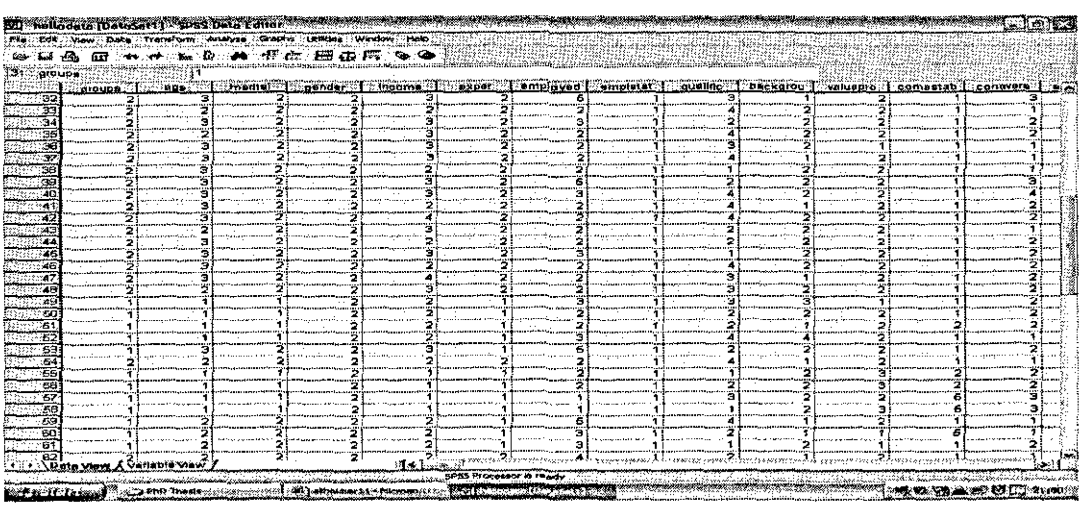
hellodata [DataSet1] - SPSS Data Editor

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
155	rwsv5	Numeric	8	0	Rank Rating of	{1, 0.7}	999	8	Right	Scale
156	rwsv6	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
157	rwsv7	Numeric	8	0	Rank Rating of	{1, 0.7}...	999	8	Right	Scale
158	rqcv1	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
159	rqcv2	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
160	rqcv3	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
161	rqcv4	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
162	rqcv5	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
163	rqcv6	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
164	rqcv7	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
165	rqcv8	Numeric	8	0	Rank Rating of	{1, 0.8}...	999	8	Right	Scale
166	rplv1	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
167	rplv2	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
168	rplv3	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
169	rplv4	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
170	rplv5	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale
171	rplv6	Numeric	8	0	Rank Rating of	{1, 0.6}...	999	8	Right	Scale

Data View / Variable View — SPSS Processor is ready


hellodata [DataSet1] - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Window Help
cmltype8 cmltype9 pskills0 pskills1 pskills2 pskills3 pskills4 pskills5 pskills6 pskills7 pskills8 pskills9 pskill10
Data View Variable View
SPSS Processor is ready


hellodata [DataSet1] - SPSS Data Editor
File Edit View Data Transform Analyze Graphs Utilities Window Help
pskill11 pskill12 response pv bv atv mv wsv gsv plv pv1 pv2 pv3
Data View Variable View
SPSS Processor is ready


hellodata [DataSet1] - SPSS Data Editor
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Data View Variable View
SPSS Processor is ready

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Date: Thu, 22 Jun 2006 11:15:35 +0100
From: Adrienne.Adrienne<A.Baker@AMEC.co.uk>
To: Z.M.Othman@lboro.ac.uk
Cc:
Subject: RE: Result Findings

Dear Mr Othman,

I would like to thank you so much for your report and the result output on your PhD study of classifying the aptitude of civil engineering project manager,

The result findings of your investigation have provided most enlightening out look of guiding the construction and civil engineering companies with the necessary information to improve the way that we have been using of selecting the right person to the right position "civil engineering project manager".

The report has been acceptable and positively informative, and having provided us with five factors as important within your model were grateful achievement.

I do agree with you that these factors are all important and makes a lot of different.

Finally we wish you all the best with your study and good luck

Sincerely yours,

Manager - Adrienne Baker
AMEC Construction Ltd

Tel: 0141 885 1234

Fax: 0141 866 7726

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