

EFFECTIVENESS OF SOFTWARE APPLICATIONS IN CONSTRUCTION PROJECT MANAGEMENT

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**The Dissertation was submitted to the Department of Civil Engineering of the
University of Moratuwa in partial fulfilment of the requirement for the Degree
of Master of Science in Construction Project Management**

Department of Civil Engineering

University of Moratuwa

April 2013

DECLARATION

I hereby certify that this dissertation does not incorporate any material without acknowledgement and material previously submitted for a degree or diploma in any university to the best of my knowledge and I believe it does not contain any material previously published, written or orally communicated by another person except where due reference is made in the text.

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ABSTRACT

Today, construction industry is becoming complex due to rapid improvement in design and technology. Completing construction project without time and cost overrun is a great challenge. In Sri Lankan condition, the need for efficient management is more urgent than ever before. In fact, inefficient construction management has contributed to long drawn-out projects in the past with inflated costs and delayed utilization. Professional construction project management input is a mandatory requirement for successful project completion and one tool the project manager can effectively use to manage the project is dedicated project management software.

This study report, research in to the application of dedicated project management software in construction management by building contractors in Sri Lanka. The focus of this research was to gather industry experience in the use and application of construction management software and to assess the difficulties face & benefits realised by the industry. It was based on a survey of local C1, C2, C3 & C4 grade contractors, engaged specially in building construction, registered at ICTAD. The industry experiences in usage of dedicated project management software were studied under three main areas of project management, planning, scheduling and controlling. This was done through a questionnaire based interview.

Over 80% of firms are using MS Project as project management software & usage was limited only for initial basic facilities provided by software and very less usage in cost & resource related activities. Providing easy administration of works, integration & approach to repetitive tasks, Force due to competitors & consultants are most important factors highlighted as reasons for usage. Non availability of trained staff & lack of interest among top management are significant difficulties faced. Only 35% of firms have a plan to develop their software systems.

Key words: Effectiveness, Software Application, Construction, Project Management

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ABBREVIATIONS AND ACRONYMS

PM	- Project Management
ICTAD	- Institute for Construction, Training and Development
GDP	- Gross Domestic Product
IT	- Information Technology
PC	- Personal Computer
DOS	- Disk Operating System
CPM	- Critical Path Method
PERT	- Program Evaluation & Review Technique
LSM	- Linear Scheduling Method
LOB	- Line of Balance
WBS	- Work Breakdown Structure
BCWS	- Budgeted Cost for Work Scheduled
BCWP	- Budgeted Cost for Work Performed
ACWP	- Actual Cost for Work Performed
EPM	- Enterprise Project Management
EPMO	- Enterprise Project Management Office
Prince 2	- Project in Control Environment methodology
PMBOK	- Project Management Body of Knowledge
WPMS	- Web based Project Management System
PM-ASP	- Project Management-Application Service Provider
PDA	- Personal Digital Assistance
ISP	- Internet Service Provider
OBS	- Object Breakdown Structure
RFQ	- Request For Quotation
PMO	- Project Management Office

CHAPTER 1

1. INTRODUCTION

1.1 Introduction

The Management of construction projects to be a challenging occupation as the environment in which projects are constructed increases in complexity. Such complexity arises from the increasing technological, social and economic forces that impact on the process of constructing the world's building and infrastructure. (Walker, 2007)

All over the world construction activity is becoming increasingly complex, day by day rapid improvement in design and technology have added new dimension to the industry. Skilled and economic used of material has become essential because of unexpected high escalation in prices and scarcity of some of the essential material of construction. Scarcity of right type of workers and rapid increase in the cost of labor wages and also location, nature, and magnitude of work have led to new techniques in construction technology and management. Continued exploitation of labor in the past has increased workers discontent and has opened up new areas of conflict. There for systemized planning and programming of works and effective management of construction project are needed to prevent drudgery and to improve efficiency. (Jeyaweerasingham, 1996).

According to the Annual Survey of Construction Industries, the total estimated value of work done by all type of construction activities of the contractors, who registered with ICTAD under western province was Rs. 62,995 million in 2008. The Highest contribution to this value has been made by the building construction sector which accounted for 45.4% of the total value of work done. (Statistics, 2010)

According to the department of Census & Statistics, in year 2007, contribution from construction industry to country's GDP is 9%. That portion takes a vital role in the economy of the country as a whole; same can be improved further by increasing the efficiency and productivity of construction industry following proper management techniques.

Poor management & disruption in cash flow, resulting from payment delays, too have affected the construction industry. Escalation of the prices of inputs in recent times

has aggravated this problem. Frequent interruption of works has been noticed due to this reason. (ICTAD, 2008)

A construction program involves a wide range of aspects such as site investigation; feasibility studies; project reports; planning for the works including method of construction and the requirement of men, materials, equipment, and finances; monitoring of work during construction; providing necessary controls from planning to the completion of the work and its maintenance when required. For the contractor it also mean his own investigation and market survey; bidding for works; planning and execution of works, settlement of contractual disputes and the realization of outstanding dues in good time. The entire process involves most complex and sensitive issues, particularly for contracting organization, which has to start with offering of the construction proposal for the work and includes the factor that carry weight in determining whether bid with adequate caution or with the acceptance of some risks which appear unavoidable because of the nature of industry in which it is placed.

Hence completing a construction project without time and cost overrun is a great challenge. This means, there are a lot of data to be handled in a short period of time; a lot of people involved; a need to be able to store data for later use; a lot of data needing manipulation using simple and repetitive calculations and most importantly a need for timely and accurate information.

How this can be achieved cost effectively and successfully? One possible mean is with the use of IT, emphasizing on computers as a tool. Here it is critical to understand what an effective information system requires. An effective information system where computer capability plays an important role has the following general conditions; (Jeyaweerasingham, 1996).

- A considerable amount of data which needs to be handled.
- A requirement to file and also present selected data when needed.
- A short time available to process data
- A relative simplicity and repetitiveness of operations for handling data
- A large number of people in the organization involved with the data going into the system or involved with the information presented by the system or both

- The availability of timely and accurate information to achieve business goals.

The construction Industry in Sri Lanka is in a very backward state compared to other developed & South Asian countries. Many factors contribute to the poor performance of the construction industry of which one is the scarce use of IT. Other sectors in economy such as banks, share market and financial institutions are using IT in a day to day operation. (Premasiri,2000).

Above condition prevails same in the Sri Lankan construction industry, even after 12 years, after the above comment was made, & the situation related to usage of project management software for planning & control aspects in management of constructing companies involved in building construction were taken in to consideration of this research.

1.2 Background

Project Management is the application of knowledge, skills, tools & techniques to project activities to meet the project requirements. Project management is accomplished through the appropriate application and integration of the 42 logically grouped project management processes comprising the 5 process groups called Initiating, Planning, Executing, Monitoring & Controlling and Closing. (PMI, 2008)

From construction industry to computer software development industry, Project Management (PM) is enjoying an unprecedented wave of popularity as a professional discipline. Also, adaptation of PM tools and practices appeals to many different industries because it is suitable to today's highly competitive business environment. As a result, organizations are widely implementing PM tools, techniques and practices.

Planning and controlling every detail is obviously impossible in a manually operated system where the extent is vast when the scale of the project increases & it will not provide the platform of process the data to get required output with expected accuracy within time scale available. With the advent of the computer software a considerably more sophisticated approach to planning and control has evolved. The development of

information technology since early nineties is reflected in the construction industry especially in communication & the management areas where it is used for planning & control.

Professional Project Management input is a mandatory requirement for successful project completion and one tool, the project Manager can effectively use to manage the project is computer software (Gunasekara, 1994)

The construction industry is fragmented due to the many stakeholders and phases involved in a construction project. This fragmentation has led to well documented problems with communication and information processing and has contributed to the proliferation of adversarial relationships between the parties to a project. This fragmentation is also often seen as one of the major contributors to low productivity in construction.

Information Technology is now routinely used in the construction industry as a tool to reduce some of the problems generated by fragmentation. The use of software improved coordination and collaboration between firms participating in a construction project, leading to better communication practices. Its benefits include an increase in the quality of documents and the speed of the work, better financial control and communications, and simpler and faster access to common data as well as a decrease in documentation errors. IT spending in Architecture/ Engineering/ Construction firms has increased significantly during the past few years, indicating that above firms are increasing their interest in software application to facilitate construction projects. (Nitithamyong, 2004)

In Sri Lanka, managing small and medium construction projects by local contractors is still being done in a very traditional manner. Progress reports including cost control; labour; material and equipment reports are prepared in monthly intervals. Progress monitoring is not carried out throughout the project. Everywhere we are told that we are in the age of optimization of planning, scheduling and controlling construction projects, yet increasingly many of our project are out of control, cost are exceeding estimates; completion times are exceeding schedules and owners are becoming increasingly dissatisfied with the status of the projects (Jeyaweerasingham, 1996)

There is no any significant change experience in the Sri Lankan construction industry relating to the aforesaid quote, where still most of projects result out of control behaviour, specially of time & cost aspects, caused due to several reasons, where one of the objective of this research is to identify to what extent the usage or non usage of project management software available has affected to this environment.

1.3 Problem Definition

Ever developing construction industry is becoming more and more complicated due to the following factors, (Zoysa, 2002)

- Rapid technological development such as involvement of modern machinery, plants and sophisticated new construction methods;
- Invention and usage of new material, components & pre-fabricated components have tremendously increased,
- Involvement of various professionals in various disciplines has vastly increased;
- Today's clients are more and more concerned about the time and cost targets as any time overrun has to be compensated with the additional cost;
- Involvement and influence of various parties such as bankers, funding agencies and financial institutions have created a situation where time and cost targets have become more and more important;
- Due to the various new procurement methods and various type of contract, the management activities have become more and more complex.

All the above listed factors reinforce the fact that even though we have invented new construction materials, methods, equipment and various modern technologies considerably, completing a project within the set time and cost has become extremely difficult unless a good project management approach with regard to planning, scheduling, monitoring and controlling is adopted.

Since the objectives of a construction firm are to maximize their profits and/or the survival among tight competition, it follows that computer software will be one of the most important tools required in managing of construction projects.

The latest software available for project management provide facilities / services in widely spread area relating to construction industry and dedicated software are now available, depending upon the requirement of organisation and its scales of needs to manage projects effectively and efficiently, despite of the size or scale of the project. Usage of these available facilities will depends on the price of the software, configuration requirement of systems, availability of trained personnel, awareness of the facilities provide in software systems, alternatives available etc in the construction industry.

In Sri Lanka, managing small and medium construction projects by local contractors is still being done in a very traditional manner. Progress reports including cost control; labour; material and equipment reports are prepared monthly intervals. Progress monitoring is not carried out throughout the project & even though the tracking, monitoring was carried out, the efficiency & effectiveness was not to the required levels. Though the industry as a whole in a stage of optimization of planning, scheduling and controlling construction project, yet increasingly many of our project are out of control, cost are exceeding estimates; completion times are exceeding schedules and owners are becoming increasingly dissatisfied with the status of the projects. This has indicated that Sri Lankan construction agencies are very often labelled as being inefficient performers, when measured against the success/ failure criteria of cost, time and quality. It is important that the construction industry make full use of the computer technology, an ideal which has not always been achieved in the past.

1.4 Objectives

Project Objectives are to find;

- To what extent software is being used in the Construction Industry for Planning, Scheduling and Monitor & Control. This will include the difference facilities provided by software & its usage levels by firms in project management activities.
- Areas where software can be used effectively in Construction Project Planning & Control. Using the data collected through survey, will try to find the activities where firms have been achieved higher performance through software usage.

- What are the key areas of Project Management where software application is needed to enhance productivity? Under this, attempt will be made to find the areas where achievements by firms show significant lags than expected, while studying the involvement of software to improve outcome.

1.5 Methodology

The research methodology comprised of following components.

- Literature survey
- Collection of data
- Analysis of data

1.5.1 Literature Survey

The prevailing literature in the area of study is deeply analyzed in this chapter. Information available in past research papers, publications of software facilities for project management, project reports etc will be considered for reference. A research undertaken on a similar area by Jeyaweerasingham in 1996, and a study conducted in the area of information technology usage in construction industry by Premasiri in year 2000 will be taken as a reference of this particular research.

Research reports, articles, publications, journals will also be referred to collect the basic information and data reference related to particular area. Internet and encyclopaedias will also provide considerable contribution for this study.

1.5.2 Collection of Data

A data collection survey will be conducted among C1, C2, C3 & C4 contractors in Sri Lankan Construction industry who involves specially in building construction. The companies list, registered in ICTAD will be used to select the required sample and will try to reach 100% of C1, 50% of C2, C3 and for C4 as sample. The collection of data will be mainly based on a questionnaire survey.

1.5.3 Data Analysis

The analysis will be mainly targeted on to find,

- Extent of software are being used in the Construction Industry for Planning & Control

- Areas where software can be used effectively in Construction Project Planning & Control
- The key areas of Project Management where software application is needed to enhance productivity.
- Difficulties faced & benefits gained by construction companies of using project management software

1.6 Main Findings

- Over 80% of building contractor firms (ICTAD grades C1 to C4) is using MS Project as their project management software tool. Some firms have been extended the usage to MS Project server facility, but it was very limited for few firms.
- Usage of software for planning, scheduling and monitoring & control aspects of project management activities were limited only for the initial basic facilities provided by software, for most of the firms and very less usage in cost & resource management activities.
- The satisfaction level of the activities, irrespective of software usage for those particular areas are also decreases along with the software usage, where this implies that, if the extent of usage will be expanded, more efficient process & outcome can be achieved.
- Depending on the type of the firm & the nature of the projects involved, there are some areas where considerable satisfaction can be attained of project management activities without adopting software techniques to the project management process.
- The building construction firms are using project management software for their projects mainly since the facility provide easy administration of works, integration & approach to repetitive tasks. One important finding of this study was the contractor firms have mentioned that, *force due to competitors, project teams & consultants* as the second most important factor for usage of project management software.

- f) Non availability of trained staff has become the most significant reason, appeared as difficulty faced by the construction firms of usage of dedicated project management software. Lack of interest among top management of utilizing latest project management software within their companies has become the second most responded reason, as the difficulties faced.
- g) Only around 35% of construction firms in the industry have a plan to develop their software systems in future to facilitate the project management activities. The rest, 65% does not have any plan of improving their systems.
- h) Easy management and administration activities & generating quality reports through the software within short period of time has become most attractive reasons under benefits gained through software usage by contractor firms. There were very few responds to the *increase profit margins & increase company reputation*.

1.7 Guides to Report

Chapter 01 - Introduction



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Background, objectives, limitations, methodology, main findings and the guide to the project report are included in this chapter.

Chapter 02 - literature review

This chapter contains literature review done in the area relevant to research topic, in detail. Content is as follows;

- Project Management Software
- Project management techniques
- Enterprise project management
- Web-based Project Management System
- Project Management System-Application Service Provider

Chapter 03 - Methodology of study

Methodology of study is described in this chapter. Developments of the study of data collection, formulation of questionnaire, have been detailed in this chapter. This chapter also gives the details of the pilot

study, how the target groups were identified and how the data collection was carried out.

Chapter 04- Detailed analysis and discussion

Detailed analysis and discussion of results are included in this chapter. The analysis was basically executed in two distinct areas, where first part was to present the raw data, which were collected through questionnaire survey, for all the contracting firms & later was processed data where comparison of results between the status of answers for specific questions within same organization & between the different type of organizations.

Chapter 05- Conclusions and Recommendations

This chapter contain an overall summary with the conclusions & recommendations drawn from the work.

1.8 Summary

The Management of construction projects to be a challenging occupation as the environment in which projects are constructed increases in complexity. Professional Project Management input is a mandatory requirement for successful project completion and one tool, the project Manager can effectively use to manage the project is computer software. The effectiveness of PM software usage will be measured among C1, C2, C3 and C4 contractor firms through a questionnaire survey & the data from a literature review and questionnaire survey will be used to analyse, to get answers to the main objectives of the study. Over 80% of firms subjected to study were using MS Project as their PM software and no any firm found of using Primavera systems. In addition, the usage of dedicated PM software for monitoring & controlling aspects was at its minimum level, by the contractor firms subjected to this study.

2. LITERATURE REVIEW

2.1 General

In chapter 2, an abstract from the literature reference made throughout the study to publications, journals, research reports, similar studies etc were included which provide the basic information of existing condition of the Sri Lankan construction industry, project management tools & techniques and its applications related to construction, available software facilities to assist various activities of construction project management.

2.2 Project Management Software

Project management software has a capacity to help plan, organize, and manage resource pools and develop resource estimates. Depending the sophistication of the software, resource including estimation and planning, scheduling, cost control and budget management, resource allocation, collaboration software, communication, decision-making, quality management and documentation or administration systems. Today, numerous PC-based project management software packages exist, and they are finding their way into almost every type of business. In the early days, however, project management software ran on big mainframe computers and was used only in the large projects. These early system were limited in their capabilities and, by today's standards, were hard to use. Some of the widely use project management software by the construction industry have been discussed below.

2.2.1 Microsoft Project

Microsoft Project is a project management software program, developed and sold by Microsoft, which is designed to assist a project manager in developing a plan, assigning resources to tasks, tracking progress, managing the budget, and analyzing workloads.

Microsoft Project was the company's third Microsoft Windows-based application, and within a couple of years of its introduction it became the dominant PC-based project management software.

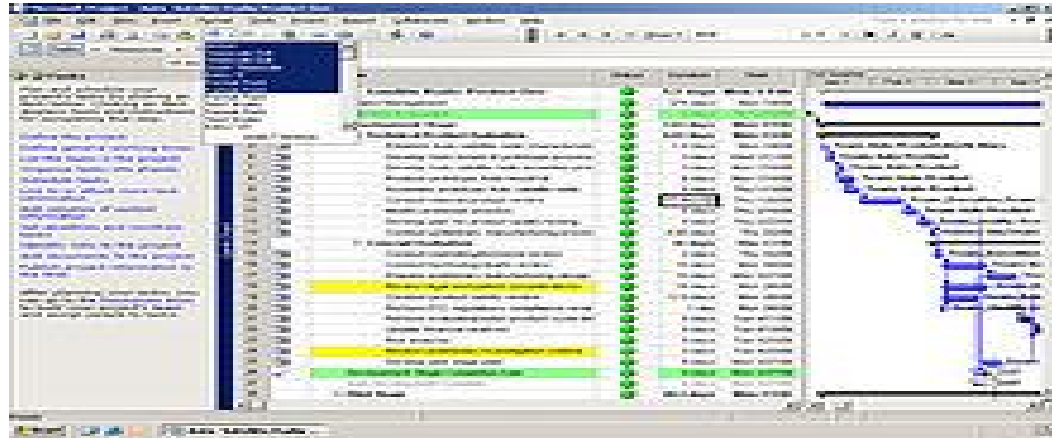


Figure 2.1: Microsoft Project - a sample Gantt chart

Project creates budgets based on assignment work and resource rates. As resources are assigned to tasks and assignment work estimated, the program calculates the cost, equal to the work times the rate, which rolls up to the task level and then to any summary tasks and finally to the project level. Resource definitions (people, equipment and materials) can be shared between projects using a shared resource pool. Each resource can have its own calendar, which defines what days and shifts a resource is available. Resource rates are used to calculate resource assignment costs which are rolled up and summarized at the resource level. Each resource can be assigned to multiple tasks in multiple plans and each task can be assigned multiple resources, and the application schedules task work based on the resource availability as defined in the resource calendars. All resources can be defined in label without limit. Therefore it cannot determine how many finished products can be produced with a given amount of raw materials. This makes Microsoft Project unsuitable for solving problems of available materials constrained production. Additional software is necessary to manage a complex facility that produces physical goods.

The application creates critical path schedules, and critical chain and event chain methodology third-party add-ons also are available. Schedules can be resource leveled, and chains are visualized in a Gantt chart. Additionally, Microsoft Project can recognize different classes of users. These different classes of users can have differing

access levels to projects, views, and other data. Custom objects such as calendars, views, tables, filters, and fields are stored in an enterprise global which is shared by all users.

2.2.2 Primavera Systems

Primavera Systems was supporting long-established products P3 and Sure-Trak, and newer P6 version. In United States, the long-standing P3 product in its various forms was used by 25% of the heavy construction industry, its predominate customer base; the next most popular software was used by 11%. Nearly 40% of general contractors with annual revenue of \$5Million to \$10Million used Primavera P3. In comparison the P6 version did not register in a CFMA 2008 survey of the United States construction industry. The P3 version to P6 version change is based in a move from DOS-type shortcut keys to mouse-based icons. The result is a software application that was once very fast to use but grounded in shortcut functions some found difficult to master, to a mouse-based application that is quicker to learn, but once mastered never achieves the same speed of use. The Primavera Project Planner DOS core launched in 1983 and the P3 Windows interface launched in 1994. Primavera systems are multiuser products that operates on networks, allowing to share data with other networks and anyone who manages projects using Primavera software.

2.3 Separating Planning & Scheduling

The planner who draws a bar chart is trying to do two things at the same time. One is planning, that is, analyzing the project into individual jobs and showing the logical relationships between them. The other is scheduling, which imposes a set of times upon the plan. (Battersby, 1964)

2.3.1 Planning

Planning is the process of thinking about and organizing the activities required to achieve a desired goal.

Planning involves the creation and maintenance of a plan. As such, planning is a fundamental property of intelligent behaviour. This thought process is essential to the creation and refinement of a plan, or integration of it with other plans; that is, it

combines forecasting of developments with the preparation of scenarios of how to react to them.

An important, albeit often ignored aspect of planning, is the relationship it holds with forecasting. Forecasting can be described as predicting what the future will look like, whereas planning predicts what the future should look like.

2.3.2 Scheduling

One of the most common project management software tool types is scheduling tools. Scheduling tools are used to sequence project activities and assign dates and resources to them. The detail and sophistication of a schedule produced by a scheduling tool can vary considerably with the features provided and the scheduling methods supported. Scheduling tools may include support for:

- Multiple dependency relationship types between activities
- Resource assignment and levelling
- The Critical Path and Critical Chain methods
- Activity duration estimation and probability-based simulation
- Activity cost accounting

2.4 Critical Path

A critical path is the series of tasks that will push out the project's end date if the tasks are delayed. The work critical has nothing to do with how important these tasks are to the overall project. It refers only to how their scheduling will affect the project's finish date. However, the project finish date is of great importance in most projects. If you want to shorten the duration of a project to bring in the finish date, you must begin by shortening (also referred to as "crashing") the critical path. (Johnson, 2007)

Project Management Tools which Project Management software can be equipped with:

Before discussing the project management tools, it is worthy to understand how the project management process i.e. planning, scheduling, monitoring & controlling with

2.4.1 Critical Path Method (CPM)

CPM is a planning technique in which a network is prepared and a sequence of network activities is defined such that if the completion of any one of them is delayed, the completion of the project will also be delayed. This sequence of critical activities is called the critical path. (Westney, 1985)

2.4.2 Progress Evaluation and Review Technique (PERT)

PERT is a network planning technique which allows us to deal with the uncertainty of the duration of the activities on our network. Using PERT we can define a most probable duration, an optimistic duration and a pessimistic duration for each activity. Statistic approximations are then used to calculate the expected duration for each activity and for the entire project. PERT may be useful way to communicate and control the probability of delay. (Westney, 1985)

2.5 Why Critical Path Method is so important?

The Critical Path Method is a powerful tool for planning and management of all type of projects. It provides a precise mathematical approach for planning, scheduling and control and allows ready evaluation and comparison of alternative work programmes, construction methods and types of equipment by changing individual activity durations, resources or relationships between activities (Jayawardana, 1995)

Further, network and its associated tools provided by the CPM help the project manager with precise information on the effect of each variation or delay in the adopted plan thus allowing identification of operations which needs remedial actions.

The use of CPM is well established in variety of industries and is very much established in the construction industry as stated above.

In addition to various other uses in variety of industries the assessment of cost of hazards may be investigated. Also, a rational approach to problems in minimizing site risks, floods, inclement weather and similar hazards can be achieved through the CPM so that the cost of these risks may be assessed and incorporated in to the programme.(Jayawardana, 1995)

Therefore, CPM is a very important and effective technique in the project management activities and hence should necessarily be incorporated in the project management software packages available for project management activities. There are various project management tools based in critical path method. They are required at various stages of a project.

The first task, which has to be carried out in CPM, is to identify (Lock, 1996)

- All the activities of the project
- All the resources required for each of the activity
- Inter relationship of these activities and
- Activity duration by considering all the constraints.

Once these tasks are finalized any project management software should be capable of accepting this information so that the project manager can effectively use for project management techniques which will be discussed below.

2.5.1 Networks

As we all are aware, network is a representation of the project plan by a schematic diagram that depicts the sequence and interrelationship of all the activities of the project. A fully developed network is a logical and mathematical model of the project based on single activity duration. This can be used to quickly establish the earliest start time, latest start time, earliest finish time, latest finish time, floats, critical path and the project duration of a project. (Clough/ Sean, 1991)

1. Activity on Arrow Network
2. Activity on Node (Precedence) Network

As the name imply, in the activity on Arrow Network, Arrows represent the activities, where as the activity on Node Network, the activities are represented by Nodes.

2.5.2 Advantages of Network Techniques;

- Increase coordination among parties and activities
- Provide sufficient details to identify the trouble spots in advance.
- Increase the user awareness of the problems involved and show the importance of certain activates in the overall project.
- Indicate optimum start and finish time for each activity

- Highlight the need for other management techniques (work study) and indicate where such techniques are mostly applicable.
- Represent the inter-relationships of all the activities.

2.6 Resource Histograms for resource planning

As we well aware, a project requires several resources such as skilled and non skilled labourers, other personnel who are engaged in construction activities as required, plant and any other things as may be required. The problem that project managers or planners encounter is to find out when they need different type of resource during the project period, how many of each category is required at different times and whether available resource are sufficient. However, if they are not sufficient what actions can be taken to overcome the problems could be easily thought off.

The resource requirement for each category of resources can be clearly seen in a resource histogram. Hence, any software package intended to be used for project management should have the facility to produce this type of resources histograms.



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2.7 Non Uniform resource requirement

Generally, when resources are assigned to an activity, it assumes that the resource usage starts when the activity commences and continues until the activity finishes. However, there are situations where a particular resource is not required until the activity has been underway for a few days. It is also possible that the resource is not consumed at an event rate through the allocated period.

2.8 Leveling of Resources

If the resource histogram indicates a lot of peaks and troughs or exceeds the resource ceiling, the non-critical activities should be moved within their floats using defined priority criteria to smooth the resources below the ceiling. If it is still impossible, the logic of the network will have to be re-arranged to accommodate resource demand.

This is in fact a very tedious process if carried out manually. So, any software package intended to be used for project management activities, should have the facilities to level resources according to a priority order against the availability to stay within the resource limit. Normally, resource levelling does not change the activity duration or resource requirements but it delays the scheduled dates. In this situation, two approaches can be made. The first is to move activities within floats or even delaying outside the floats to accommodate the demand of resources with the availability and checking the schedule to see whether it is acceptable. The second is to assign more resources during the peak periods (Jayawardana, 1995)

Therefore, any software package intended to be used for project management activities should necessarily have the facility to experiment by using different levels of availability or modify the Network logic and then re-schedule to see the impact of alternative approaches. (Jayawardana, 1995)

When using specially designed project software, levelling typically means resolving conflicts or over allocations in the project plan by allowing the software to calculate delays and update tasks automatically. Project management software levelling requires delaying tasks until resources are available. In more complex environments, resources could be allocated across multiple, concurrent projects thus requiring the process of resource levelling to be performed at company level.

2.9 Calendars

The most important feature, which should be incorporated in computer packages developed for project management purposes, is the facility to create working calendars. Working calendars allow defining working and non-working days and hours. The project schedules the activities to perform only during the working days and hours as specified. In addition to these base calendars, the software packages should be able to define resource calendars as well. The schedule considers that resources are available according to the calendars and the plan is adjusted to suit the availability.

2.10 Scheduling

Once the project is planned using the critical path method including the resources, the planned dates must be communicated in a schedule for execution. The schedules can be prepared in the form of a bar chart, histogram, table or a report. Therefore, any project management software package should have the facility to produce required schedules based on project management tools as herein described.

Given below are some of the common schedules, which are considered as paramount important for project management activities (Jayawardana, 1995).

2.10.1 Bar Charts (Gantt Chart)

Bar charts “Gantt Chart” is perhaps the most extensively used tool for scheduling. Its versatility arises from the simplicity of its preparation; its use and its capacity to accommodate various forms for effective communications.

A Gantt chart is a type of bar chart, developed by Henry Gantt in the 1910s, that illustrates a project schedule. Gantt charts illustrate the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts also show the dependency (i.e., precedence network) relationships between activities. Gantt charts can be used to show current schedule status using percent-complete shadings and a vertical "TODAY" line.

Although now regarded as a common charting technique, Gantt charts were considered revolutionary when first introduced. In recognition of Henry Gantt's contributions, the Henry Laurence Gantt Medal is awarded for distinguished achievement in management and in community service. This chart is also used in Information Technology to represent data that has been collected.

Gantt charts have become a common technique for representing the phases and activities of a project work breakdown structure (WBS), so they can be understood by a wide audience all over the world.

A common error made by those who equate Gantt chart design with project design is that they attempt to define the project work breakdown structure at the same time that

they define schedule activities. This practice makes it very difficult to follow the 100% Rule. Instead the WBS should be fully defined to follow the 100% Rule, then the project schedule can be designed.

Although a Gantt chart is useful and valuable for small projects that fit on a single sheet or screen, they can become quite unwieldy for projects with more than about 30 activities. Larger Gantt charts may not be suitable for most computer displays. A related criticism is that Gantt charts communicate relatively little information per unit area of display. That is, projects are often considerably more complex than can be communicated effectively with a Gantt chart.

Gantt charts only represent part of the triple constraints (cost, time and scope) on projects, because they focus primarily on schedule management. Moreover, Gantt charts do not represent the size of a project or the relative size of work elements, therefore the magnitude of a behind-schedule condition is easily mis-communicated. If two projects are the same number of days behind schedule, the larger project has a larger effect on resource utilization, yet the Gantt does not represent this difference.

Although project management software can show schedule dependencies as lines between activities, displaying a large number of dependencies may result in a cluttered or unreadable chart.

Because the horizontal bars of a Gantt chart have a fixed height, they can misrepresent the time-phased workload (resource requirements) of a project, which may cause confusion especially in large projects. A related criticism is that all activities of a Gantt chart show planned workload as constant. In practice, many activities (especially summary elements) have front-loaded or back-loaded work plans, so a Gantt chart with percent-complete shading may actually mis-communicate the true schedule performance status.

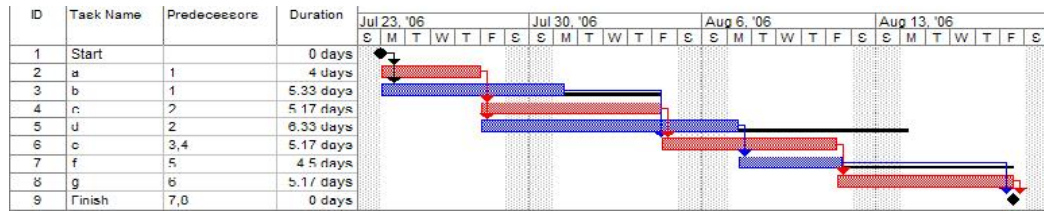


Figure 2.3: Gantt Chart

2.10.2 Reports

Producing various reports indicating detailed information of a project such as early start date, early finish date, late start date, late finish date, float and other information, which gives an immediate picture of which alternatives are most important in getting the project completed on time, is extremely important. Hence the project management software packages, which are intended to be used for project management activities specially, should be equipped with these tools to provide those reports whenever required.

2.11 Progress Monitoring & Control

Progress monitoring and control are very important in the project management when a project is underway, to make sure that the project completes on schedule. Maximum benefits of project planning and scheduling cannot be obtained unless a proper monitoring and controlling is carried out. The important tools available for this purpose include bar charts and monitoring and controlling reports (Jayawardana, 1995)

(1) Bar Chart Target Comparison

When a project is underway, the target plan (original schedule of base line plan) and the actual progress in the same bar chart indicate the actual position of project.

(2) Progress Monitoring reports

It should be able to compare the schedule plan (baseline plan) with the actual dates in a report. Then the potential problems can be flagged with LATE notice, and the schedules activities can be marked with OK.

Therefore, it is important for any project management software packages to give this kind of information in a report.

The areas covered by most of these so-called project management software packages are as follows. (Jayawardana & De Mel, 1994)

- Project Planning & Scheduling
- Resource Management
- Progress Monitoring & Control
- Cost Control & cash flow forecasting
- Presentation of information through various reports

2.12 Cost Control

As we are aware, cost controlling is the most important aspect in project management. There are various techniques available for this purpose. Cost Histogram, Cash Flow reports, Cumulative Curves (S-curves) and cost control reports are the most important tools available for project management activities. It is clear, that each activity requires a mix of labor, materials, plant and other resources. The problem of the project manager is to track the actual cost for each resource, each activity and for the whole project with the budgeted cost and take necessary actions for controlling the cost in case it exceeds the budgeted cost (Jayawardana, 1995)

This process is very difficult task if carried out manually.

2.12.1 Cost Control Technique

Cost control is the gathering of cost data, the relationship of actual costs to estimated cost and the reporting to management on the current cost status. Since the objectives of construction firms are to maximize their profit and/or the survival among tight competition, it follows that cost control is the most important type of control required on construction projects.

2.12.2 Cash Flow Forecasting

In project cash controlling, it is necessary to take in to account the timing and the amount of the various payment and receipts. A cash flow is the transfer of money into

or out of the project, considering the timing and the amount of the transactions. Cash flow forecasting means estimating of the cash, position of the project by considering the net effect of cash inflow and cash out flow, and timing of transactions. Net cash flow of a project during a period is the difference between cash in and cash out during that period. Therefore, cumulative cash flow is the net cash flows of all the preceding periods. (Gunasekara, 1994)

The cash flow forecasting provides an early warning system to predict, possible insolvency. Accordingly, the contractor will have time to plan and make preventive actions as appropriate. Some of the advantages of cash flow forecasting are;
To adjust the work schedules of existing contracts so that minimum capital will be locked-up.

- To negotiate the credit facilities with suppliers.
- To negotiate payment terms with clients
- Facilitate to make decisions whether to invest in fixed assets such as construction plant, building etc
- To negotiate overdraft limits with bankers.



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Cash flow forecasting systems should be monitored regularly to have a meaningful result. Cash flow diagrams were able to give cash at any time period, the Maximum negative cash and when it occurs, when self funding is required, and how much finance is costing. (Gunasekara, 1994)

2.12.3 Cost Control Reports

Cost control reports can details or summarize the quantities of resources applied to each activity or the cost expended for each activity. These reports show values for budget, actual to date, actual this period, estimate to complete and estimate at completion (forecast), and variance between the budget and the forecast values. Cost control report can be prepared as a one-page summary report of the costs of the project, i.e. a snapshot of the project cost status of a particular time.

Some of the tools, which the project management software packages, should be facilitates for are as follows,

- (1) Actual Vs Target cost histograms

(2) Earn Value Analysis

The performance can be determined using earned value, which calculates the value of work satisfactorily completed, based on a completed target plan. Measuring performance involves three key indicators. Budgeted Cost for Work Scheduled (BCWS), Budgeted Cost for Work Performed (BCWP), and Actual Cost for Work Performed (ACWP). BCWS is the planned budget to date, BCWP is the budgeted value of work done to date and ACWP is the actual amount spent to date for the work performed.

The difference between the BCWS and BCWP is the schedule variance. The difference between the ACWP and the earned value (BCWP) is the cost variance.

(3) Cash Flow histogram and Project Cost Curves

Projected cost histograms with cumulative cost curves indicate the cash pattern in the future. This will no doubt help the project manager in his decision making so as to make sure that the project will be completed within the targets.



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(4) Cash Flow Reports

These reports are used to view a diagram that which shows planned and actual costs for your project over time. Costs are broken down by resource type (work, material, and cost). An indicator shows if planned costs exceed baseline costs.

(5) Cost Reports

Use this report to view a bar graph with budget cost, baseline cost, planned cost, and actual cost illustrated over time.

2.13 Enterprise project management

Enterprise Project Management (EPM), in broad terms, is the field of organizational development that supports organizations in managing integrally and adapting themselves to the changes of a transformation.

In recent years, with general adoption of (IT) governance practices, Enterprise Project Management has become more specific: whereas in the 1990s focus was generally on the management of the single project, in the subsequent decade the focus lay more on the fact that a project is likely to not be the only one in the enterprise. The project co-exists with many other projects in the enterprise, or may be part of one or more programs. It may utilize (human) resources that are shared among other projects.

In order to facilitate governance, it has become essential to be able to manage, monitor, and assess the status of all projects (and other assets, of course) in the enterprise, through a set of (preferably uniform) Enterprise Project Management processes, methods and application packages. Typically, organizations that adopt an Enterprise Project Management way of working might set up a Project Management Office (PMO)/ Enterprise Project Management Office (EPMO, which is said to be more successful than a traditional PMO in addressing the priorities of the organization as its scope is enterprise-wide, might select and adopt a Project Management Methodology like PRINCE2, PMBOK (or create a proprietary method) or follow the concepts of IPMA Competence Baseline as a foundation for development and certification of project managers and their knowledge, experience and behaviour. They might even select and implement a software system to support Enterprise Project Management.

An even more recent evolution in Enterprise Project Management is to not only plan and track the existing set of projects, but to create a portfolio (per budget size, per calendar year, per budget year, per business line, etcetera) of existing and future (demand) projects. This is called Project Portfolio Management. Just like with a portfolio of shares, Project Portfolio Management is the activity of selecting which projects to keep in portfolio (because of their anticipated value) and which ones to discard (because of their obsolescence or because they will not yield the value that was initially calculated). Project Portfolio Management includes the creation of various scenarios to decide which is the most optimal portfolio (for a certain year, business, budget, etcetera). Once the contents of the portfolio are agreed upon, it is key to constantly scrutinize how the individual projects are evolving in terms of quality, cost and schedule.

From an IT management perspective, Enterprise Management essentially means enterprise-wide network administration, which is becoming increasingly complex. The corporate network environment is no longer tied to a single vendor, let alone a single platform. More and more, corporate intranets are multidomain, multiprotocol, multiplatform systems. They contain hardware and operating systems from a number of different, competing vendors. This situation creates administrative overhead that can easily make the cost of owning such networks prohibitive for all but the largest and most profitable organizations.

Implementing an Enterprise Project Management toolset needs to be considered in light of the organization's Project Management Maturity and the methodologies, processes and governance structures that are currently in place. There are many organizations that can support such implementations.

2.14 Web-based Project Management System

Web-based Project Management System (WPMS) enhance construction project documentation and control and to revolutionize the way in which a construction project team conducts business. WPMS is an electronic project-management system conducted through the Extranet, which is a private network that uses Internet protocols to transmit information. The system is only accessible by a project team, but team members can be located in different organizations. It basically provides a centralized, commonly accessible, reliable means of transmitting and storing project information. Project information is stored on the server and a standard Web browser is used as a gateway to exchange this information, eliminating geographic and boundary hardware platform differences. Fig. 2.4 illustrates the basic functional scheme of WPMS.

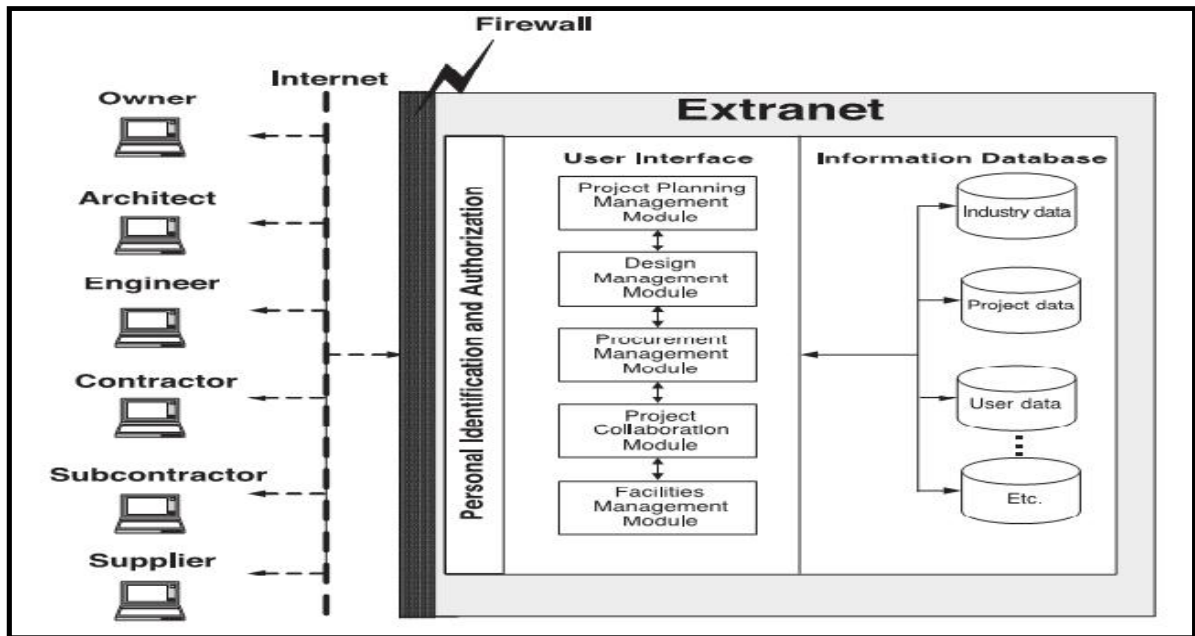


Figure 2.4: Functional scheme of WPMS (Scacchi, 2007)


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Project Management System-Application Service Provider (PM-ASP), is becoming popular because it requires minimal technical, financial and human resources to develop and operate. Since PM-ASP is outsourced to an ASP, it requires no effort to develop and maintain the system in-house, involves comparatively low initial investment and overhead cost, and is convenient for keeping up with cutting-edge technology. Therefore, it is a viable solution for a small or midsized firm that does not have enough resources to maintain an in house IT department and/or a sophisticated networking infrastructure. In addition, PM-ASP is also capable of performing electronic commerce, such as online bidding and procurement, which are difficult to develop and conduct through in house WPMS.

2.15.1 Current features of PM -ASPs

a. Document management

This feature establishes a single location to store general project-related files, such as project photos, contracts, drawings, specifications, cost data, etc. It

allows team members to manage, track, and organize these files in a central location.

b. Project workflow

This feature allows team members to collaborate electronically using Request for information, change orders, field notes, correspondence, submittals, punch lists, daily logs, and standard or customized forms.

c. Project directory

This feature stores general information (phone number, address, and e-mail) of project team members in a central directory. Therefore, specific information for each project participant can be easily retrieved when needed.

d. Central logs and version control

This feature allows team members to track who accessed files or down loaded a particular document, as well as when the file was edited and uploaded to the system. It also includes the use of digital signatures to identify and verify an individual before entering the data or transmitting information.

e. Advanced searching

This feature allows team members to find documents or specific details within documents through the entire log. This is the key feature that enables users to locate documents more easily, compared with situations where files are located in different offices, on different servers, or scattered about on local computers.

f. Conferencing and white-boarding

This feature allows team members to share applications and documents concurrently using the virtual whiteboard and to apply comments online. Theoretically, a whiteboard and notes could also be saved and attached to other workflow forms such as Request for information.

g. Online threaded discussion

This feature is a communication tool similar to a newsgroup and e-mail that allows a “threaded” discussion to take place online. It provides an open forum that displays a sequential record of messages and responses about a particular topic. Team members post questions, responses, and comments and have a permanent record of the discussions and decision process surrounding an issue. For a sensitive topic, it can also be protected by a secured password.

h. Schedule and calendar

The calendar feature allows team members to coordinate project events or meetings in a centralized agenda. Team members can then copy events or meetings to their standard software, such as Microsoft R Outlook and Eudora R . The schedule feature allows team members to create project schedules on line or to convert project schedules created by standard scheduling tools, i.e., Microsoft R Project, Primavera P3e/c k, and Sure Trak to an online working schedule. A view of the bar chart and the capability of modifying information and assigning resources can also be done using the schedule feature. Alerts with direct links to the task in question are provided to team members having overdue items. The schedule feature can also be integrated with the calendar feature to quickly view milestones at a glance.

Project camera

This feature allows a project team to monitor construction sites remotely using web-based cameras and transfer live photos of the job sites directly to their computers. These photos can then be used to share progress, resolve issues and questions, and minimize site visits.

i. File conversion

This feature supports file conversion to displayable formats to be shown through a web browser. It may also enable marking and adding notes for these converted files.

j. Wireless integration

This feature allows team members to use wireless devices such as pagers, mobile phones, and smart phones to access the project information database. It may also allow team members to input or edit project information via wireless devices and

transfer this information back to the centralized servers. This feature is very well suited for onsite personnel.

k. Archiving of project information

This feature allows a project team to copy the entire project database to a set of compact discs after the completion of a construction project, creating a comprehensive record of the entire project website with its associated databases and transaction logs. A project team thus can have all project records necessary for any disputes and the future operation and maintenance of the facility.

l. Financial service

It is normal in a construction project that a project team must secure financing before the project starts. This feature provides lenders the ability to collaborate with borrowers and suppliers in the sourcing, under- writing, closing servicing, analyzing, and securing of project loans.



Bidding and procurement processes typically involve issuing RFQ s and responding to RFI s. This feature streamlines bidding and procurement processes associated with the purchases of equipment, specialized material s, and services. Team members can issue RFQs, track all new and pending transactions, review and compare bids received from material or service suppliers, and conduct e-procurement on line. It may also facilitate transactions that require an exchange of information, such as design documents, drawings, and specifications.

2.15.2 Potential benefits of PM-ASPs

PM-ASPs offer construction firms numerous advantages over the current inter organizational information infrastructure by providing access to project data and communication that is platform and application independent. All that is required is Internet access and a We b browser. PM-A SPs are also location independent since the systems can be accessed wherever there is Internet access and a Web browser. Communication can be either synchronous or asynchronous, and individuals can access project database anytime or multiple team members can collaborate in real-

time. In addition to enhancing communication and access to project information, PM-ASPs also provide several potential advantages over in-house WPMS. Following are some of the advantages repeatedly cited in literature.

a. Cost advantage

PM-ASP uses numerous centralized application servers and data warehouses instead of concentrating power in the desktop computer as is currently done. In this case, what is left on the user's desktop is a stripped-down network computer that communicates with applications and data servers via the network. Experts predict that individuals and corporations will own very minimal software and will rent most of what they need from Service Providers and other network operators. Therefore, PM-ASPs potentially provide savings in time and resources compared to in-house solutions, which can be costly, time consuming, and maintenance-intensive, and many require a high degree of expertise by the system administrator and user to implement.

b. Outsourcing advantage

Although it is possible to develop in-house WPMS that would have almost the same functionality as PM-ASPs, there are many arguments against it. McFarlan presented a model that helps firms understand when it is advantageous to outsource IT services, linking the IT outsourcing decision to the strategic impact of the existing information systems and the portfolio of applications the firm has under development. In highly competitive, transaction intensive, knowledge based industries like banking and insurance, both the information systems and the development portfolio play what McFarlan categorizes as a strategic role. Outsourcing such a core process can lead to loss of critical competitive skills and of control of important proprietary information. On the other hand, in industries like large-scale process manufacturing or, in this case, the construction industry, IT plays only a support role. It is much more of a commodity and hence, although necessary, it is not central to the firm's competitive position. By this reasoning, many computing functions in the construction industry are good candidates for outsourcing.

There are several advantages to outsourcing portions of construction industry computing that mainly relate to scale. Small and medium scale firms, which make up

the majority of the construction industry, are able to take advantage of sophisticated communications and computing software that they would otherwise be unable to afford. Even larger firms in the construction industry may have difficulty justifying the relatively high investment required to develop the functionality of WPMS. A number of currently available PM-ASPs are actually spin-offs from design and construction firms that saw an opportunity to take their in-house computing systems to scale.

2.15 Summary

Two popular software available for PM functions in the industry, MS Project & Primavera systems were introduced at the beginning of this chapter. The difference between planning and scheduling were clearly described & the processes of planning, scheduling, monitoring & controlling of project management process were explained. The concepts of critical path, the importance of critical path analysis were discussed along with the other techniques such as PERT charts, Network diagrams, Gantt charts etc available for PM practices, describing advantages of some of them. Resource histograms, assignment, resource leveling, non uniform resource requirements of a project were taken in to consideration in the following section & usage of different type of calendars were also taken in to consideration. Under the section Monitoring & Controlling, cash flow forecasting, cost controlling, techniques such as Earn Value analysis, Cash Flow histogram and Project Cost Curves (S-curves), cost histograms etc were explained, in addition to the monitoring techniques such as bar chart comparisons, progress reports etc.

Enterprise project management & its usage were summarized in the next section of the report & introduction of Web-based project management systems, Project Management System-Application Service Provider software were there to understand the latest developments of the software industry for PM practices.

3. METHODOLOGY OF STUDY

3.1 General

This chapter will contain detailed descriptions of methods followed to achieve the main objectives of this research study. Methods followed for literature survey, limitations of the study & narrow down of scope, identification of target group to collect data, formulation of questionnaire format, details of pilot survey & the steps to be followed for data collection were explained under this chapter 3.

3.2 Methodology

As to commence the research, by referring to the previous researchers, research reports & literature, the problem was supported by adequate evidence which was formed a solid base to understand the problem & initiation of study which was targeted to a clear objective.

Literature Survey

The prevailing literature in the area of study was deeply analyzed at the beginning of the study. Information available in past research papers, publications of software facilities for project management, project reports etc were considered for reference. A research undertaken on the same area by previous researches and a study conducted in the area of information technology usage in construction industry by R.W.R Premasiri in year 2000 were taken as references of this particular research.

Research reports, articles, publications, journals were also referred to collect the basic information & data reference related to particular area. Internet & encyclopaedias were also provided considerable contribution for this study. Interviews and discussions with experts & experienced engineers in the construction industry at initiation stage provided a sound understand & valuable collection of information, not only in the area of study itself, but usage of software facility in the construction industry in Sri Lanka as a whole, its usage, problems facing, expected developments of software facility usage etc.

A questionnaire was formulated through the knowledge & information gained from literature study & was used as the source of collecting particular information for the study from selected organizations in the industry.

Filling questionnaire through interviews and discussions with various personnel, especially the senior managers with civil engineering background in the construction organisations were selected as the best method for this type of study for the following reasons.

- a) Interviews and discussions give greater control over the respondents and provide opportunity to direct questions to obtain detailed explanations and justifications for various opinion and decisions.
- b) It is possible to achieve a complete response with different categories of a sample and then ensure the statistical validity of the results.

In addition, literature survey was carried out continuously for understanding the background and to collect necessary information for the research.

3.3 Limitations of Study

Since the usage of information technology in construction industry covers a vast area, the study was limited to the software which provides dedicated project management facilities to the construction firms. The knowledge & exposure gained by author during academic studies for master's degree in construction project management & the experience harnessed from the industry, working as an engineer in consultancy firms for more than seven years, made the basis to limit the study for dedicated project management software usage. The basic facilities provided by those software for planning, scheduling, monitoring & controlling were taken in to account in this study.

Construction projects can vary from simple house construction to mega projects such as dams and other monsters; it was wise to limit the study to one category of structures, namely the buildings to give the results a statistical value. Building industry was selected considering the following,

- a) The authors practical experience is limited to building industry
- b) Most of the contractors are building contractors

- c) Tough competition among local contractors, which leads to adopting of improved management techniques.

The contractors registered under ICTAD as contractors were taken in to consideration in this study. Among the registered contractors in ICTAD, the study was further limited to C1, C2, C3 and C4 which the results were more specific than conducting the study for entire contractor firms.

Since the number of contractors registered in ICTAD was more than 275 firms & considering the difficulty of reaching all the firms for this study, it was limited to take 100% of C1 firms & 50% of C2, C3 & C4 firms as the sample.

3.4 Formulation of Interview Questionnaire

It was identified that formulation of a questionnaire to obtain relevant information is one of the major tasks requiring careful planning and considerable experience in computer application in construction management. A questionnaire was formulated in order to gather industry experience in the use and application of dedicated software in construction management and also to cover other objectives of the study. Further, as construction managers are busy in their business it was thought necessary to have prepared questions with proper sequence to collect all necessary information. A discussion with four building contractors and two experts, working in engineering consultancy firms who are using software for construction project management was carried out prior to set this questionnaire. Based on the information and extracted details from literature survey, the following major sections were identified to be included in the interview questionnaire.

1. General Organisational Information
2. Software Usage for Project Management: General
3. Usage of Dedicated Project Management Software
4. User Satisfaction
5. Difficulties faced
6. Benefits gained

The questionnaire used in the interviews consisted of four pages of questions, out of that half page of instruction and information. The questions have to be answered in the following ways,

1. Yes / No (ticking or underline)
2. Ticking on alternatives
3. Word answers (optional)
4. Answers to be marked on a given scale

The questionnaire was designed to gather data in the following areas.

- Section 01 & 02: Information about the company, the ICTAD grading and how long the company is used to apply software for project management
- Section 03: Usage of Project Management Software
- Section 03: To determine the level of software usage in the main functional areas of project management for planning, scheduling, monitoring & controlling works of projects. Under this section, a scale was introduced, which consist of five step ascending scale, can be used to express the extent of user satisfaction of individual tasks, independent of software usage, as shown in questionnaire. The tools available in dedicated project management software for different functions were considered under this section, which will summarize at the end, the extent of usage the facilities available in project management software by selected categories of contractor firms in Sri Lankan construction industry.

As the first step, planning tools were considered. Different basic activities/techniques available in software manuals for planning were abstracted & included in this section of questionnaire. That list of activities/techniques will provide the extent of usage by a particular firm; since the usage was recorded through Yes/No type ticking box & the satisfaction of each activity was recorded using the scale provided, along with each particular activity, irrespective of software usage.

A sample format is as follows;

<u>Activity Description</u>	<u>Software Usage</u>	<u>Quality of Output</u> (Not depends on Software usage)
To find start/finish/durations	☐ Yes / ☐ No	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Two similar sections were introduced for scheduling and for monitoring & control.

◆ Section 04

User satisfaction of particular project management software uses by the organizations, in the areas of time, cost & resource management were taken into consideration in this section. A scale was introduced to indicate the level of satisfaction & the factors affected for satisfaction or dissatisfaction were also collected through separate questions.

◆ Section 05

Difficulties faced by construction companies in using of project management software were considered in section 05. The reasons identified through the literature reviews, discussions & interviews were summarized & presented in a one question, where ticking on alternative type question was included with provision to answer in priority order, if there were more than one reason.

- ◆ Section 06 & 07
- Benefits gained through software usage for project management & future development expectations were considered in these two chapters. The knowledge gathered through literature reviews, discussions & interviews were summarized & presented in a one question, where ticking on alternative type questions were included with provision to answer in priority order, if there were more than one reason.

3.5 Pilot Study

In order to make sure that sufficient and necessary data is collected through questionnaire survey, to fulfil the objectives of the study, a pilot survey was carried out after discussions with some leading contractors & also with engineering consultancy firms. A data collection using questionnaire & discussions with four building contractors and two experts who are using computers for project management, working in engineering consultancy firms were carried out prior to set the questionnaire. The data collected through this pilot survey was made necessary changes and improvements in the interview questionnaire before final launch.

3.6 Identification of Target Group

Only the companies registered under ICTAD in grades, C1, C2, C3 and C4 were selected who engaged especially in building constructions in year 2010 as the target group for the study & distribution was as follows;

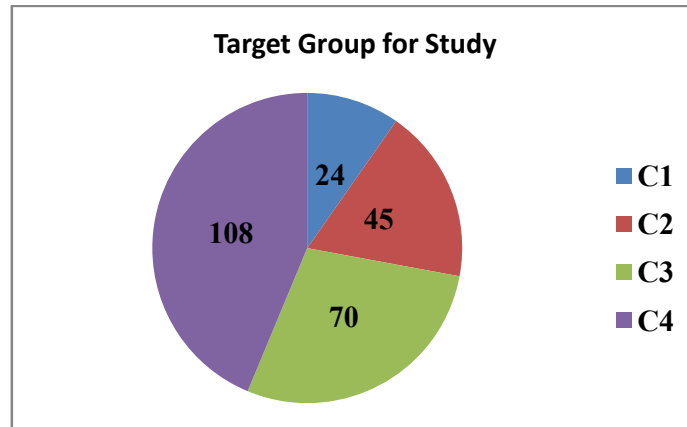


Figure 3.1- Target Group of the Study

Above chart indicate the number of companies registered in ICTAD in year 2010 under each category. Considering the difficulty of reaching all the above firms through a questionnaire survey, the numbers were limited as follows to represent a fair sample in the study.

- ♦ C1 - 24 nos (100%)
- ♦ C2 - 23 nos (50%)
- ♦ C3 - 35 nos (50%)
- ♦ C4 - 75 nos (50%)

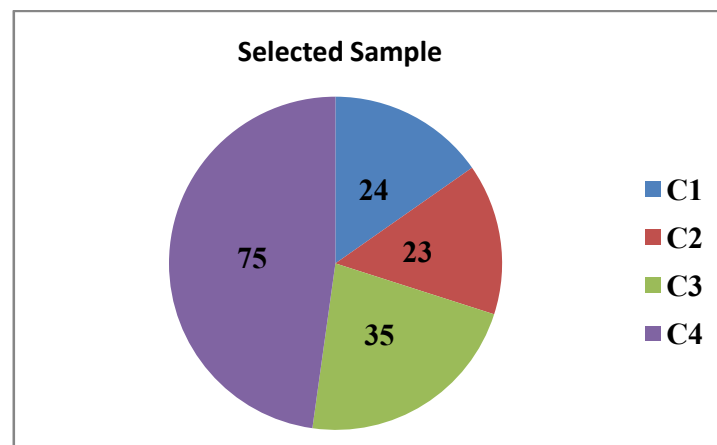


Figure 3.2- Selected Sample for the Study

3.7 Data Collection

3.7.1 Information from Literature Study

Many literature including text books, especially on techniques for effective construction management, research reports, journals, central bank annual reports of Sri Lanka were referred to gather knowledge, information related to the study. Internet, Wikipedia provided a great support to search some data, where making reach to an information very easy.

3.7.2 Questionnaire survey

Interviews were held with the senior management staff members, project planners in the construction firms to gather data & to fill up the questionnaire where, it was held as face to face at the beginning of data collection & later reached the relevant companies through emails & internet, after providing the background of the research & the direction to fill the questionnaire, since reaching particular people in the organizations were extremely difficult due to their busy schedules.

The questionnaire was formulated & conducted the interview with the concept of putting the interviewee into a friendly discussion in order to get the genuine answers without any distortions, as much as possible.

3.8 Summary

The processes starting from literature survey, limitation of the study were explained in detail, in first two sections of this chapter. The study area was limited to dedicated software usage for project management functions by building contractor firms in Sri Lanka who has registered in ICTAD as grade C1, C2, C3 & C4. Developing the questionnaire for data collection were explained with the considerations made while formulating the format, the way of reaching target group, measures of getting the accurate & correct answers/feedback from interviewee were, along with supporting data & information. Selection of a sample to collect data, conducting pilot study as guidance to the whole of the study were described in next two sections & finally the process of collecting data for the study through literature & questionnaire were described in chapter 3.

4. ANALYSIS & DISCUSSION

4.1 General

The data collected through questionnaire survey conducted among the selected building construction firms were analysed within the framework designed at the beginning of the research. The data were analysed basically as raw & processed data and the outcomes are presented in graphical, tabular & in descriptive formats. Separate analysis of data & presentation has been done for each planning, scheduling and monitoring & controlling activities in this chapter.

4.2 Analysis and Discussion of Results

The analysis was basically executed in two distinct areas, where first part was to present the raw data, which were collected through questionnaire survey, for all the contracting firms & later was processed data where comparison of results between the status of answers for specific questions within same organization & between the different type of organizations.

Presentation of Raw Data:

In certain circumstances, it was found that the raw data gives a real picture of the existing situation. In such situations every attempt was made to list raw data in descending order of importance based on the proportion of responded contracts either favourably or unfavourably.

Presentation of Summarized or Processed data:

In other cases, data was summarised after taking the whole picture into account and by giving due weightings to all comments and suggestions expressed by contractors. This method is more useful when presenting similar ideas given in various forms by different contractors.

Throughout the questionnaire survey, it was impliedly proved that all the construction firms, under category C1, C2, C3, C4 are using software for its operation works & managing projects, at least in any means, in Sri Lanka.

A summary of the sample selected for data collection & the achievement at the end was tabulated & presented in the below table.

#	Contractor Grade (ICTAD)	Registered in ICTAD in year 2010	Sample		
			Target	Data Collected	% Achievement
1	C1	24	24	13	54%
2	C2	45	23	11	48%
3	C3	70	35	13	37%
4	C4	148	75	14	19%

Table 4.1: Sample details of the study (building contractor firms)

The study & analysis was based on the assumption that the sample which have been collected the required information will provide a general overview of the category of construction companies it contains.

The one of very first questions asked from all the contractors was reasons of why they use software for project management activities, in the organization. Most of the respondents (68%) included the reasons in a priority order where rest were mentioned only one reason. Considering the reason at its 1st priority position, the following table was generated, where general overview of why the companies tends to use project management software.

Reason	ICTAD Grading			
	C1	C2	C3	C4
<i>Easy Administration works, Integration & approach to repetitive tasks</i>	50%	54%	12%	49%
<i>Standardizing company formats</i>	6%	9%		17%
<i>Forced due to competitors, Project teams, Consultants</i>	32%	9%	52%	17%
<i>To reduce cost</i>	12%		24%	
<i>Desire to keep up to date with development</i>		18%	12%	17%

Table 4.2: Reasons for using software for Project Management

The majority of the companies have indicated that, *easy administration works, Integration & approach to repetitive tasks* as the main reason of using software systems for their project management activities. For C1 companies, the percentage was 50, where for C2, C3 & C4 the percentages were as 54, 12, 49 respectively. Between the figures found out, a clear difference has been appeared in C3 & rest of

the categories where for C3, they felt less regarding usage of software for project management in *easy administration*, and considered a completely different view as reason for usage which was *Forced due to competitors, Project teams, Consultants*.

One of the main reasons where these dedicated project management software have been introduced was to make it easy of the complex administrative works of a project and its content, as well as to address the repetitive processors / systems in an effective way.

A clear reason, which will fall in the 2nd position of the list, is *forced due to competitors, project teams and consultants*. Only the C3 companies responded with 52% rate that the reason for usage of software as mentioned above. C1 category indicated this as the 2nd reason & even the C3 shows similar status, from the figures obtained. The result here reflect one aspect of the Sri Lankan construction industry which as the contractors, they do not use, or do not want to use the software facility available for planning, control & monitoring works, where consultants & other leading bodies already get use of those facilities and expect the same from the contractors. Another cause is that the competitor's usage of these facilities will affect & challenge the status of a particular company, where they tend to use such a facility or more advance facility to compete with rivals.

Reducing cost by using software was another reason indicated in the responds, which will fall to third place of the list. Addressing to repetitive works in efficient way, effective administration and some data base management will provide the basis for cost reduction of organizations.

Standardizing company formats, Desire to keep up to date with development are shown less priority than the rest. Specially, the latter "Desire to keep up to date with development" which will be a leading factor for the development of the individual organizations, and the industry as a whole is at a place with minimum interest of the construction companies.

Next finding was the type of software mostly uses by the construction companies in the industry, which was Microsoft Project for their planning, scheduling, monitor and controlling works. 100% of C1 & C3 companies, 91% of C2 & 86% of C4 companies

indicated the usage of Microsoft Project as their main software for project management.

15% of C1 & 7% of C4 category responded that usage of MS Project Server, along with the Microsoft Project as the main management software tool in the organization. No one has mentioned that the usage of Primavera system as their project management software which indicate the low popularity of Primavera systems in the country. The results are tabulated in the below table;

Contractor Category	Type of Software			
	MS Project	MS Project Server	Primavera	Any Other
C1	92%	15%		
C2	91%	9%		
C3	100%			
C4	88%	7%		14%

Table 4.3: Usage of Dedicated PM Software
(though some firms mentioned MS Project Server as one of the software in use, further inquiries confirmed that this response was due to lack of understanding between MS Project & MS Project Server Software)

From the general perspectives of the dedicated software usage in the building construction field in Sri Lanka, exploring the extent of usage of particular features of these software, were taken in to account & the section start from this point will present findings related to most common & main features relate to project management software. Planning, scheduling, monitoring & controlling areas were taken in to consideration in this study as the selected aspects of project management activities. For each & every activity, whether the feature is being used within the organization, the efficiency level of particular activity in term of satisfaction were measures through the questionnaire survey & the results are summarizes as follows;

4.3 Planning

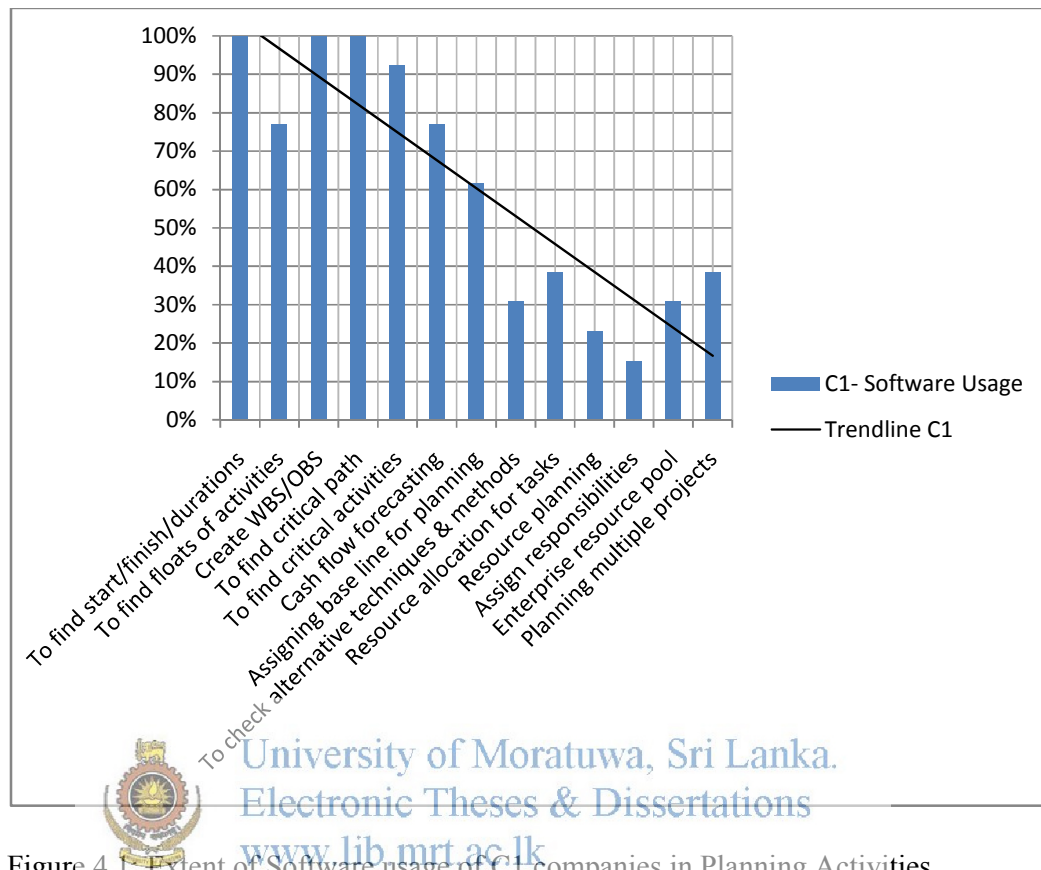


Figure 4.1. Extent of Software usage of C1 companies in Planning Activities

For creation of work breaks down structures, OBS, to finding start, finish & durations, filter of critical path of a project, these software are being used 100% by C1 contracting firms. Finding critical activities, floats of activities lies above 75% limit of responses. When it comes to cash flow & its forecasting, the usage of project management dedicated software were approximately 78% of rate of responds, in C1 category.

Assign baseline for the plan, which is an important feature of proper monitoring & controlling of the progress, was done by 60% of the firms where balance 40%, follow the plans during construction, without a baseline.

All the C1 category firms marked that they do more than one project, at a particular time considered, but only 40% of firm use the facility available in software for planning & managing multiple projects, effectively. Planning & maintaining resource

pool, allocating resources, checking of alternative methods & techniques were at a level of below 40% of the respondents.

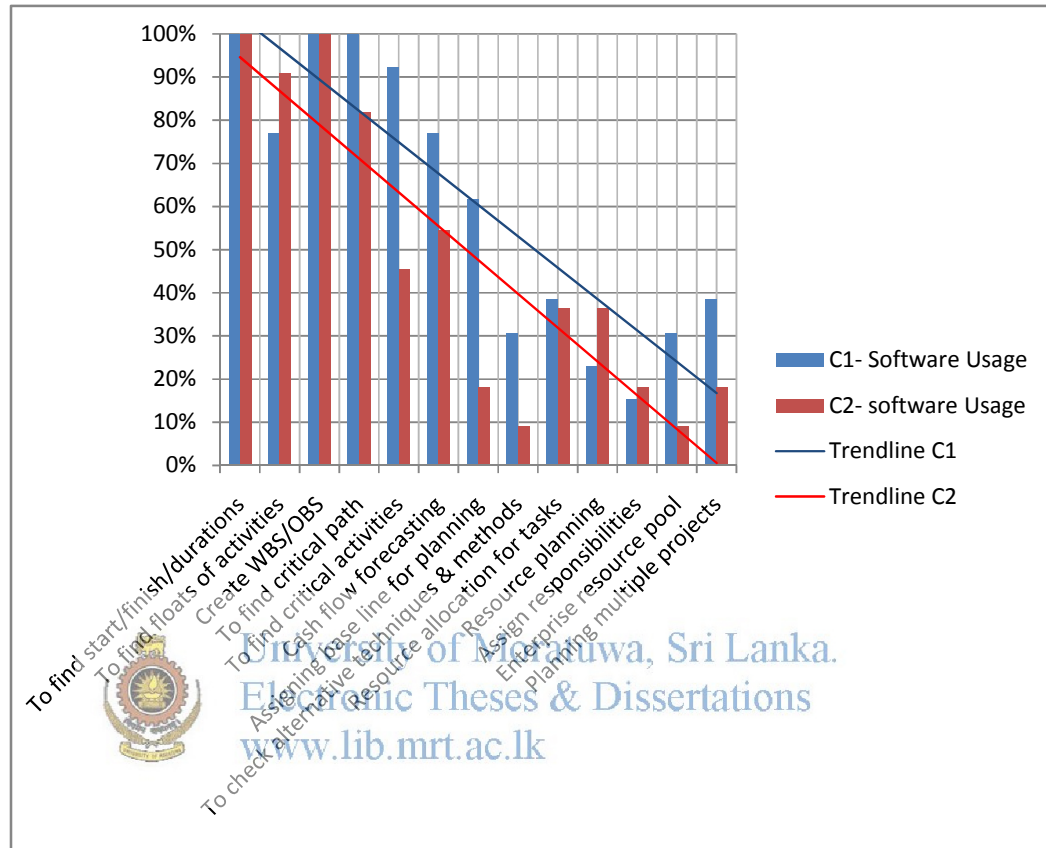


Figure 4.2: Extent of Software usage of C1 & C2 companies in Planning Activities

Figure 4.2 shows a comparison of usage of software for project management activities between C1 & C2 firms. Apart from some difference in the areas of *finding floating of activities & resource planning/ allocation*, other activity usage of C2 firms show a similar pattern as in C1, with little descend than the percentage values of C1. Some improved behaviour in *resource planning & allocation* of C2 firms than C1 is a significant factor of the above outcomes.

Collectively, both C1 & C2 indicated that they hardly use the facilities for resource planning, allocation, resource pools, and multiple project management available in dedicated software packages, for their day to day project management aspects. These results give a implied picture that most of the leading construction firms in the industry use the initial features like, WBS, timing activities (start, duration, finish),

critical path etc of a software, but less likely to use of more detailed features like resource activities, multiple project handing, resource pools etc.

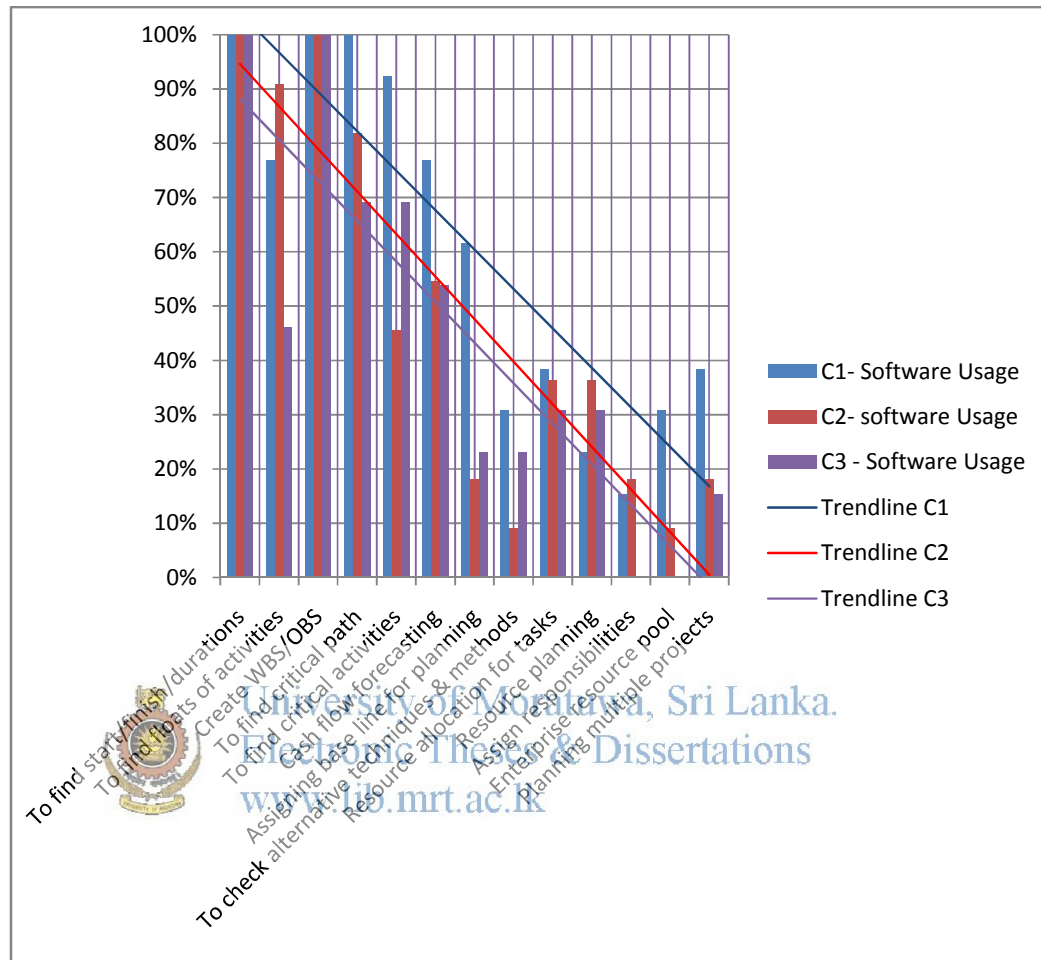


Figure 4.3: Extent of Software usage of C1, C2 & C3 companies in Planning Activities

The pattern of usage of software features in C3 category firms are almost similar to C2 category except few places, one is there are no any use of Enterprise resource pool, Assigning responsibilities. Initial features of creating work break down structure, critical path analysis, calculation of dates, durations are commonly use in C3 construction firms.

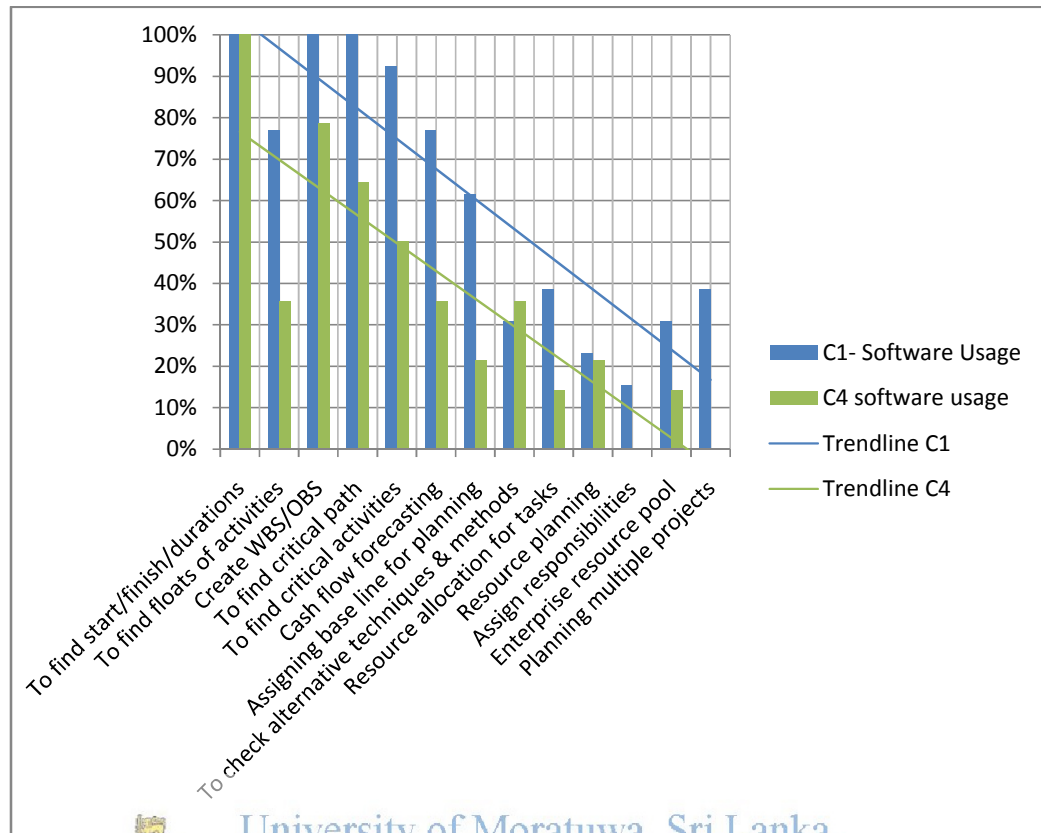


Figure 4.4: Extent of Software usage of C1 & C4 companies in Planning Activities: comparison

C4 category software usage is comparatively lower than the rest of the firms subjected to this study & considerable extent of project management work are undertaken by manual or using ordinary software, for example MS office etc. Calculations of durations / finish dates, creating work break downs are at the high percentage level where as the figures are 100%, 79% respectively. Some firms use the facility to find critical path & activities on it where the responded rates were 64% & 50% respectively.

Resource planning, allocation for tasks were at a lowest level (21% & 14% respectively) in C4 firms where they used to depend on handling the resource still in the traditional way, manually & with assistance of ordinary office software. Assigning base line for the plan was done only by 21% of the firms, subjected to study, where it will create unfavourable condition for monitoring & controlling the program throughout the project, using dedicated software.

Satisfaction in Planning, Independent of Software Usage:

C1 firms

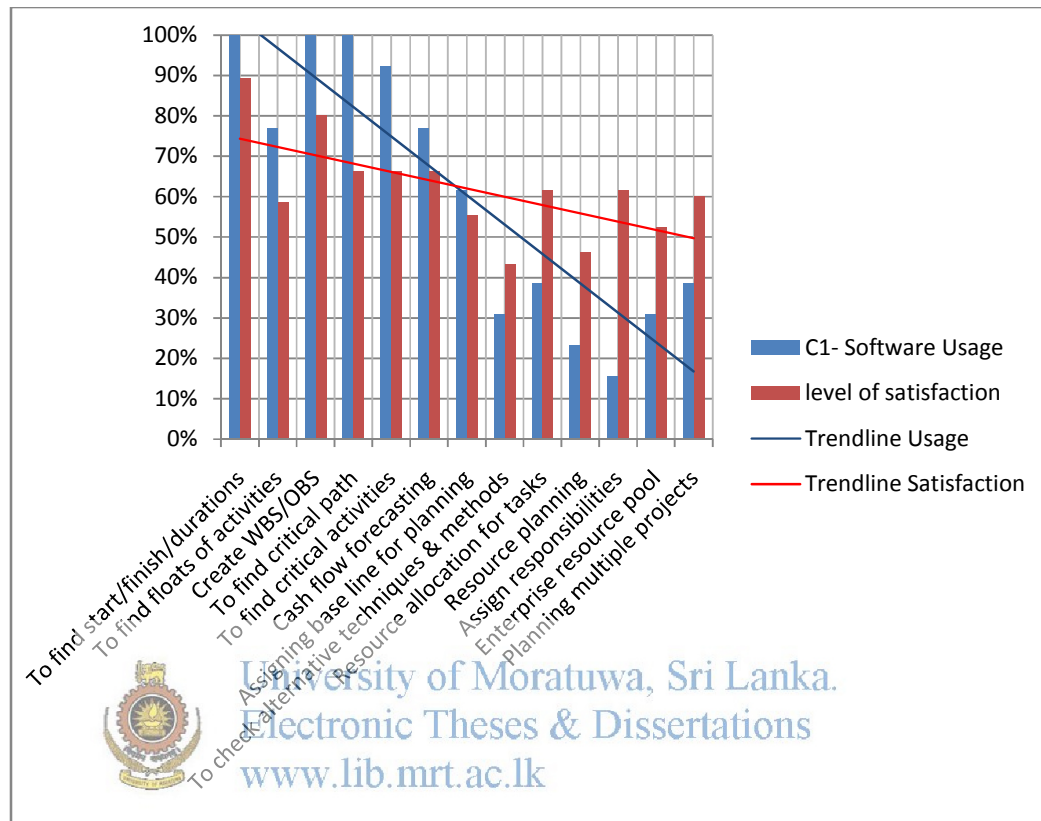


Figure 4.5: Extent of Software usage Vs level of satisfaction of particular activities (C1)

In the graph shown above presents the extent of usage of dedicated project management software features by C1 construction companies versus the quality of each activity in terms of their understanding within the organization, independent of the software usage. Adding further, it explains the satisfaction of management of particular activities which are executed by project staff for managing projects with or without using the software facilities. For example, there may be a situation where a company doing resource planning & allocating resources to different projects/activities efficiently, using a manual method or just by using MS Xcel format.

C1 companies have responded in the survey that all the firms (100%) use the project management software to find;

- Start, Finish times & durations of projects

- Create work breakdown structures
- To find critical path

Whereas their satisfaction indicators for the above tasks were, 89%, 80% & 66% respectively.

4.4 Scale used for analysis

none	poor	average	good	excellent
1	2	3	4	5
7%	20%	40%	67%	100%

Table 4.4: scale used for analysis

Development of scale:

Example: abstract from questionnaire

<u>Activity Description</u>	<u>Software Usage</u>	<u>Quality of Output</u> (Not depends on Software usage)
To find start/finish/durations	☐ Yes / ☐ No	1 2 3 4 5

If the response was , then $\{(3+2+1) / (1+2+3+4+5)\} * 100 = 40\%$

Analysis of the data for C1 firms, above results provide the basis to facilitate one of the main objective of the project to find how extent the software are being used & the how efficient they get use of the facilities available. Even though the company uses the facility available for above particular activities by 100%, still the management responded that the outcome is much below than anticipated figures. Finding start, finish dates & durations has been reach to a level close to 90% where the finding critical path still lies below 67% line, which should be a higher figure where, this will lead to success of the project, by managing the critical activities throughout the span, by identifying the path & activities at initial stage.

Usage of facilities in cash flow forecasting was 77% where level of satisfaction shows 66% which will lead to a good satisfaction rate, as per the scale shown above. Assign base line for planning technique was used by 62% of the C1 firms & the generated satisfaction level was 55% in the scale where it will fall close to an “average” level of

satisfaction in the organizations. Assigning a base line for the project plan will be one of the most important steps which should follow at the planning stage of a project, where it will provide the basis for easy monitoring & controlling of the project versus the initial plan.

Next, the following activities of planning, where the usage by C1 firms are below 50% level, are taken in to consideration.

- To check alternative techniques & methods
- Resource allocation for tasks
- Resource planning & usage of enterprise resource pool
- Assign responsibilities
- Planning multiple projects

Even though the usage figures found through survey was below 50% of the above activities, satisfaction figures were at a average, close the “good” of the scale being used.

#	Activity Description	% usage of Software	% satisfaction
1	<i>To check alternative techniques & methods</i>	31%	43%
2	<i>Resource allocation for tasks</i>	38%	62%
3	<i>Resource planning</i>	23%	46%
4	<i>Assign responsibilities</i>	15%	62%
5	<i>usage of enterprise resource pool</i>	31%	52%
6	<i>Planning multiple projects</i>	38%	60%

Table 4.5: % usage of software features Vs level of satisfaction (C1)

This will reflect that there are some activities in project management where the firms can achieve the targets or part of it, without using dedicated software facilities for project management. For example, assigning responsibilities shows a 62% satisfaction, almost the “good” level of satisfaction as per the scale of C1 firms, without any software usage. They are able to manage the activity through manual methods efficiently & planning multiple project activity is also providing the similar behaviour.

In Sri Lankan context, depending on the scale of the project undertaken by the C1 firms, only limited features of the facilities are being used for their project management aspects & rest of the activities are handled through manual or using office software systems & some data management systems.

However, the possibility of increasing the level of satisfaction through software usage has to be studied further & the data available up to this point will not support to answer the question. The reasons why the firms use or not using software facilities in construction project management will be discussed latter of this report.

C2 firms

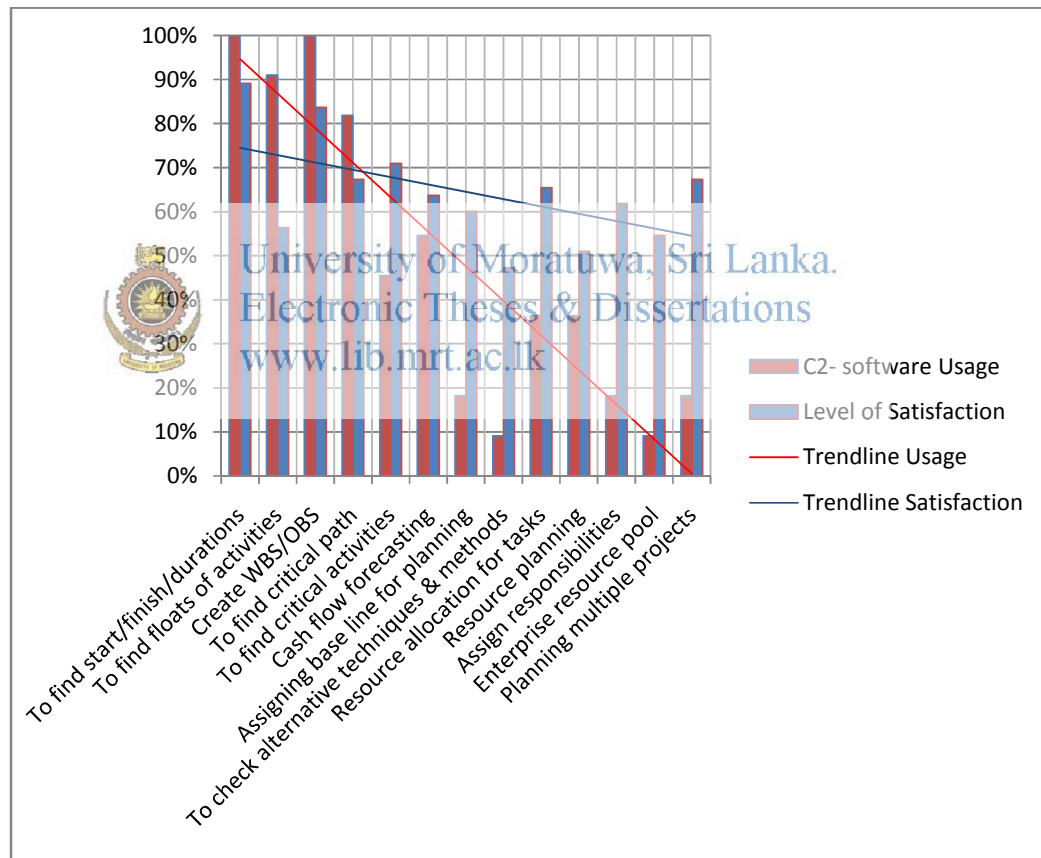


Figure 4.6: Extent of Software usage Vs level of satisfaction in particular activities (C2)

100% usage of software to find start, finish, durations, creating WBS are indicated in the responses received from C2 firms and usage of find critical path & activities are also at a level above 70% line. This reflects that these firms got the usage of the

software facilities for above mentioned activities & get the benefit of it. Cash flow forecasting were done more than 50% of firms where level of satisfaction will fall at 64% level in the scale & means “good” satisfaction.

Software usage of resource planning & allocation for tasks are at 36% usage level & satisfaction of allocation of resources was 65% in the scale, where resource planning was at 51%.

Usage of software for base lining the plan, checking for alternative methods, assign responsibilities, enterprise resource pool & planning multiple projects were at a minimum level where maximum figure goes only up to 18%. The satisfaction levels for the above items were above 50% for all except the item checking alternative methods where the level was 47%. These were level of satisfaction falls between “average” and “good” region of the scale where such achievement was made with minimum usage of dedicated software for project management.

C3 firms

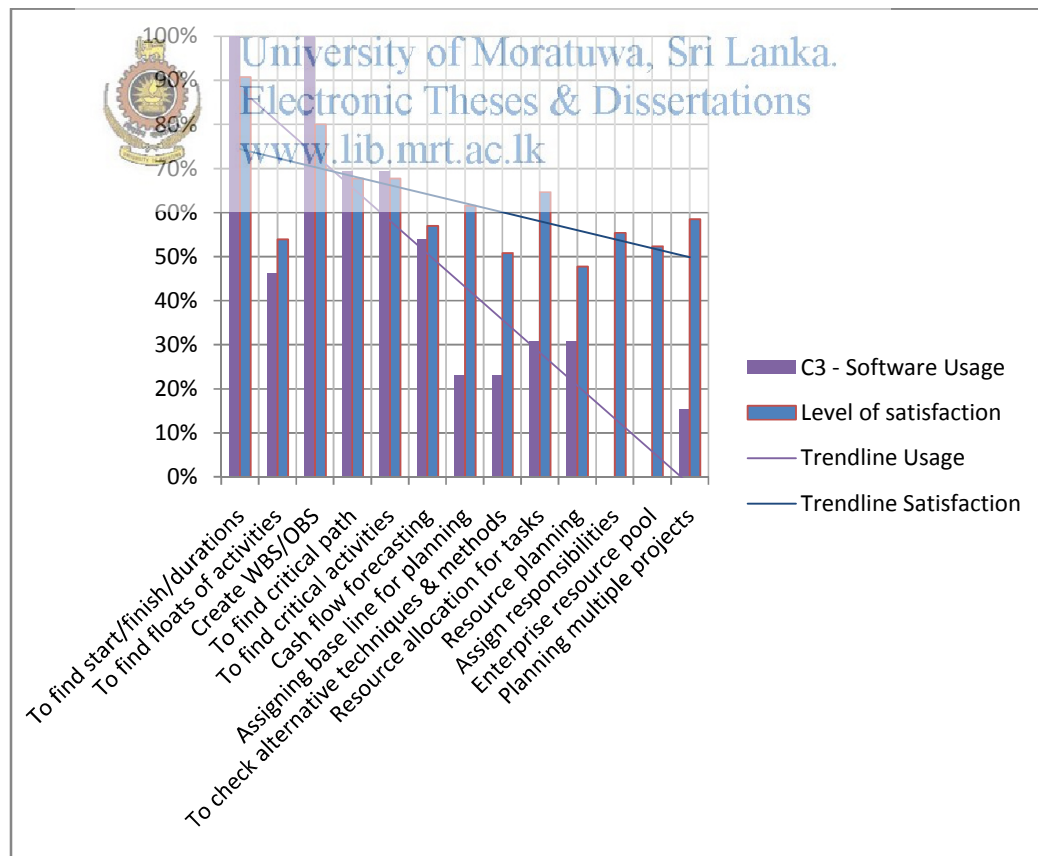


Figure 4.7: Extent of Software usage Vs level of satisfaction in particular activities (C3)

Creating work break down structures & finding start, end & duration were at 100% usage level of C3 category firms as shown in the figure above. The qualities (satisfaction) of same activities are above 70% which means that the facilities are used effectively to achieve maximum outputs of particular activities. Finding critical path & critical activities using software were at a 70% margin, where the satisfaction level of both items were also in the range “good” with a 68% figure in the scale. Cash flow forecasting usage was 54% since the level of satisfaction was also a closer value, 57% (good level of satisfaction).

Following activities were hardly implemented through the software by C3 firms meanwhile the satisfaction levels of each shows a “good” level in the scale used.

Please see the table below;

#	Activity Description	usage of PM Software %	% satisfaction
1	Assign baseline for plan	23%	62%
2	To check alternative techniques & methods	23%	51%
3	Resource allocation for tasks	31%	65%
4	Resource planning	31%	48%
5	Assign responsibilities	0%	55%
6	Usage of enterprise resource pool	0%	52%
7	Planning multiple projects	15%	58%

Table 4.6: % usage of software features Vs level of satisfaction (C3)

C4 firms

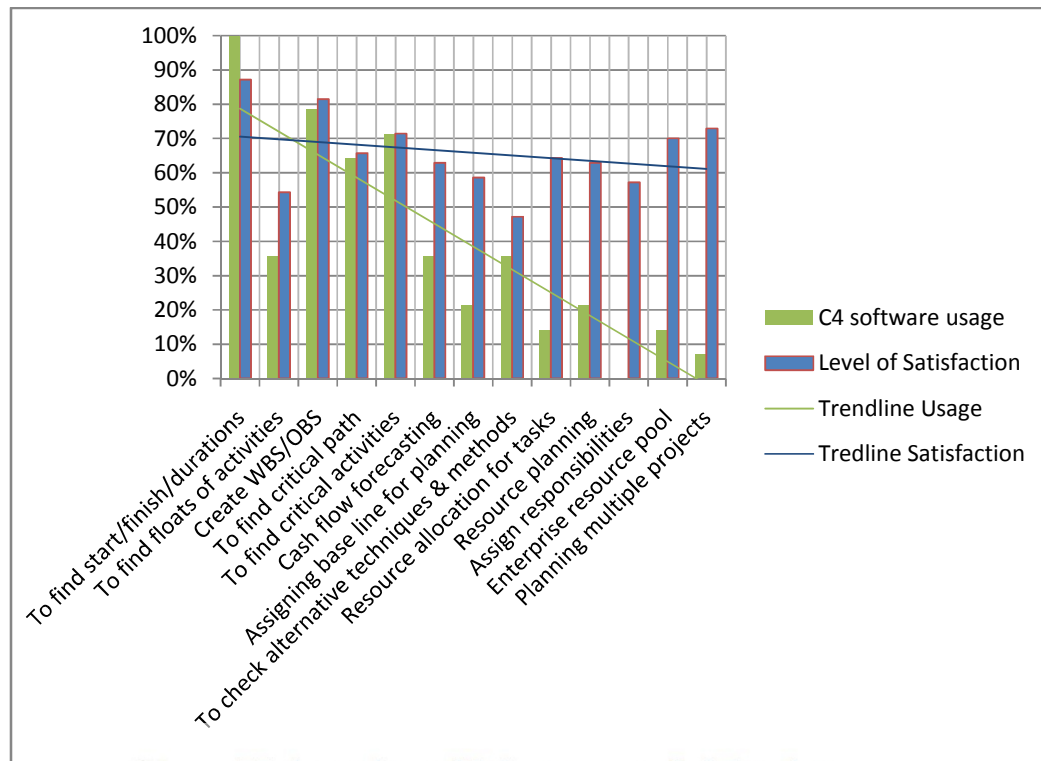


Figure 4.8: Extent of Software usage Vs level of satisfaction in particular activities (C4)

The first parts of the x axis of the graph were at higher usage & satisfaction level, as in the previous three categories & when more advance facilities were concerned, usage of software were clearly descending but maintaining the satisfaction level in an “average” or “good” level.

A summary of usage of project management software & level of satisfaction of all four categories of firms are tabulated below;

#	Activity Description	% usage of PM software				Level of satisfaction (%)			
		C1	C2	C3	C4	C1	C2	C3	C4
1	<i>To find start/finish/durations</i>	100 %	100 %	100 %	100 %	89 %	89 %	91 %	87 %
2	<i>To find floats of activities</i>	77 %	91 %	46 %	36 %	58 %	56 %	54 %	54 %
3	<i>Create WBS/OBS</i>	100 %	100 %	100 %	79 %	80 %	84 %	80 %	81 %
4	<i>To find critical path</i>	100 %	82 %	69 %	64 %	66 %	67 %	68 %	66 %
5	<i>To find critical activities</i>	92 %	45 %	69 %	71 %	66 %	71 %	68 %	71 %
6	<i>Cash flow forecasting</i>	77 %	55 %	54 %	36 %	66 %	64 %	57 %	63 %
7	<i>Assigning base line for planning</i>	62 %	18 %	23 %	21 %	55 %	60 %	62 %	59 %
8	<i>To check alternative techniques & methods</i>	31 %	9 %	23 %	36 %	43 %	47 %	51 %	47 %
9	<i>Resource allocation for tasks</i>	38 %	36 %	31 %	14 %	62 %	65 %	65 %	64 %
10	<i>Resource planning</i>	23 %	36 %	31 %	21 %	46 %	51 %	48 %	63 %
11	<i>Assign responsibilities</i>	15 %	18 %	0 %	0 %	62 %	62 %	55 %	57 %
12	<i>Enterprise resource pool</i>	31 %	9 %	0 %	14 %	52 %	55 %	52 %	70 %
13	<i>Planning multiple projects</i>	38 %	18 %	15 %	7 %	60 %	67 %	58 %	73 %

Table 4.7: Summary of % usage of PM software & level of satisfaction

4.5 Scheduling

The facilities available in project management software for scheduling tasks were studied in this section and the extent of usage & the satisfaction of each activity irrespective of software usage were recorded in the questionnaire.

The results for C1, C2, C3 & C4 firms of extent of project management software usage for scheduling tasks can be shown graphically as follows;

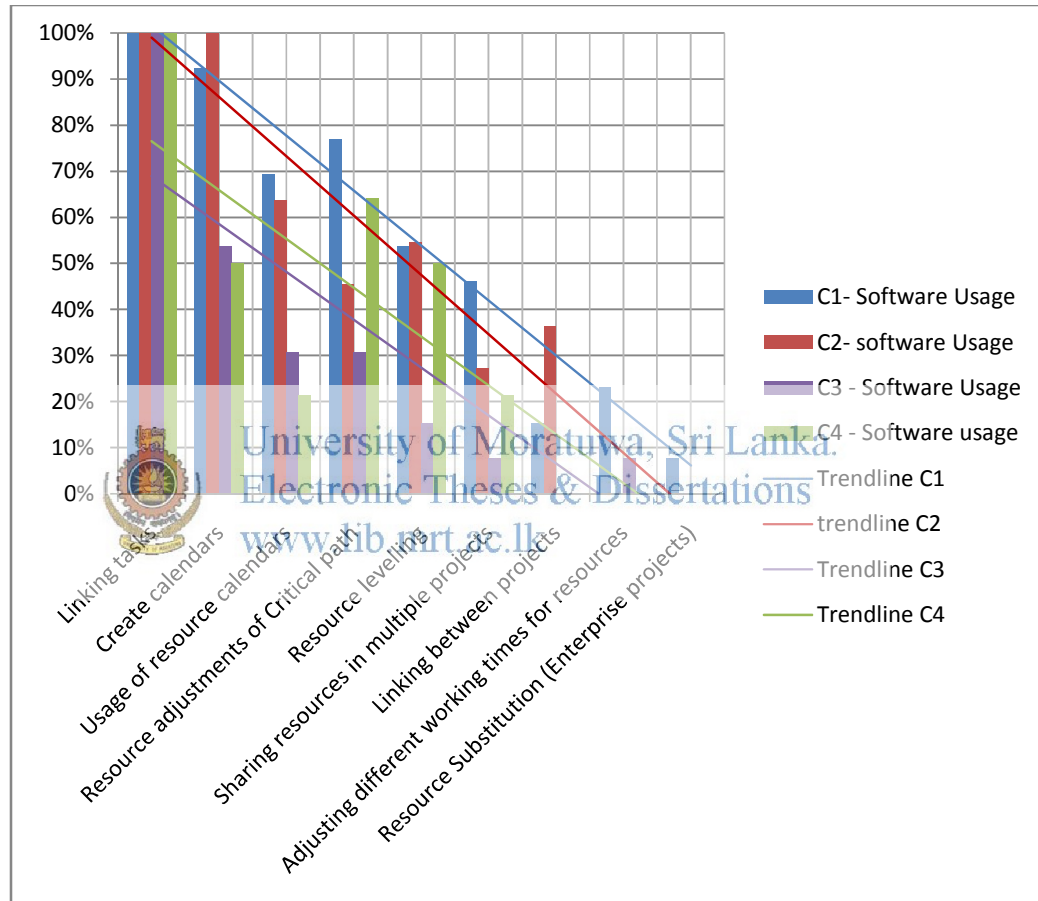


Figure 4.9: Extent of Software usage for scheduling (C1, C2, C3 & C4)

All the firms use basic facility like linking tasks by 100% & gradually decrease with other facilities, which are the activities; the planners are allowed to schedule their programs in a detailed & deeply manner. Resource levelling tasks are used mostly by C1, C2 & C3 firms where the extent of usage is below 50%, as in the above graph. The feature *linking between projects* are mostly used by C2 firms where the percentage of usage was 36% & the usage of C1 firms was 15%.

Satisfaction levels

C1 firms

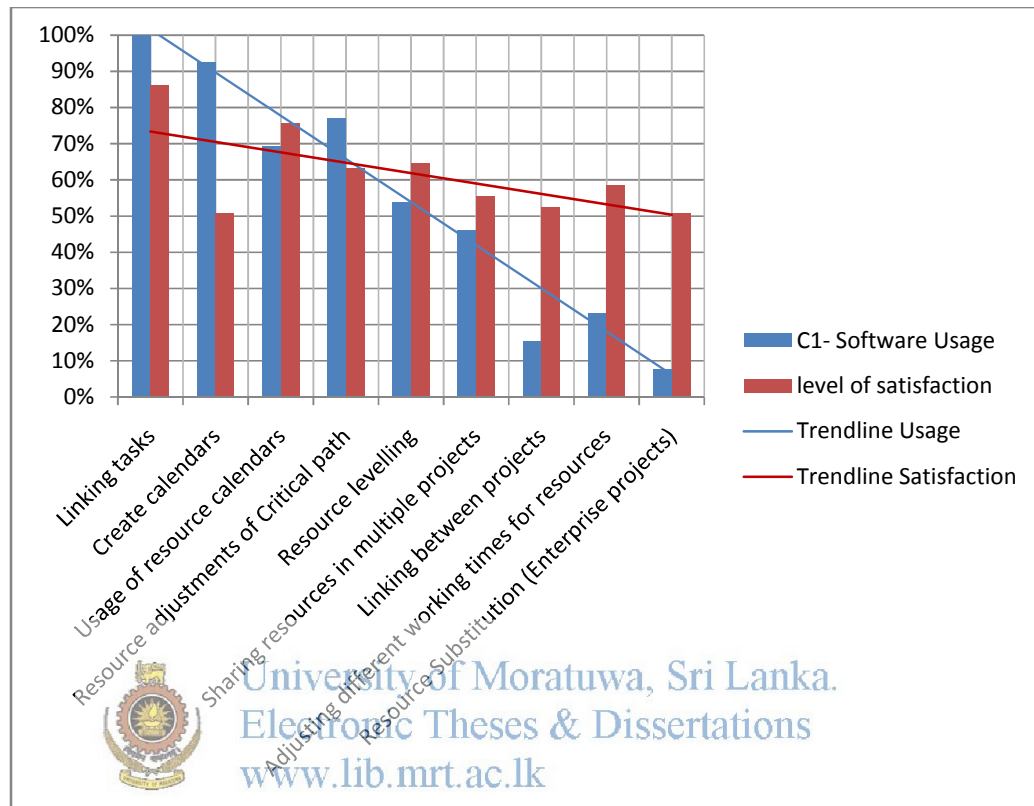


Figure 4.10: Extent of Software usage for Scheduling Vs level of satisfaction in particular activities (C1)

All the C1 firms indicated over 50% satisfaction for all scheduling activities within their organizations, independent of the software usage, i.e. their satisfaction may have been achieved through usage of project management software or with only manual systems.

Resource adjustments of critical path & Create calendars activities were managed using software by C1 firms; the usages were 77% & 92% respectively where satisfaction level showed 63% & 51%. Though the firms use software in maximum for above two particular activities, satisfaction figures shows a lower value than anticipated. This may be due to effects from external factors, beyond the control of planning stage.

Linking between projects, Sharing resources in multiple projects, Adjusting different working times for resources activities were hardly managed using software by C1 firms, but with over 50% satisfaction of activities. This condition indicate that there are some activities which can achieve certain level of satisfaction (above 50%) using manual or traditional methods, without using project management software.

C2 firms

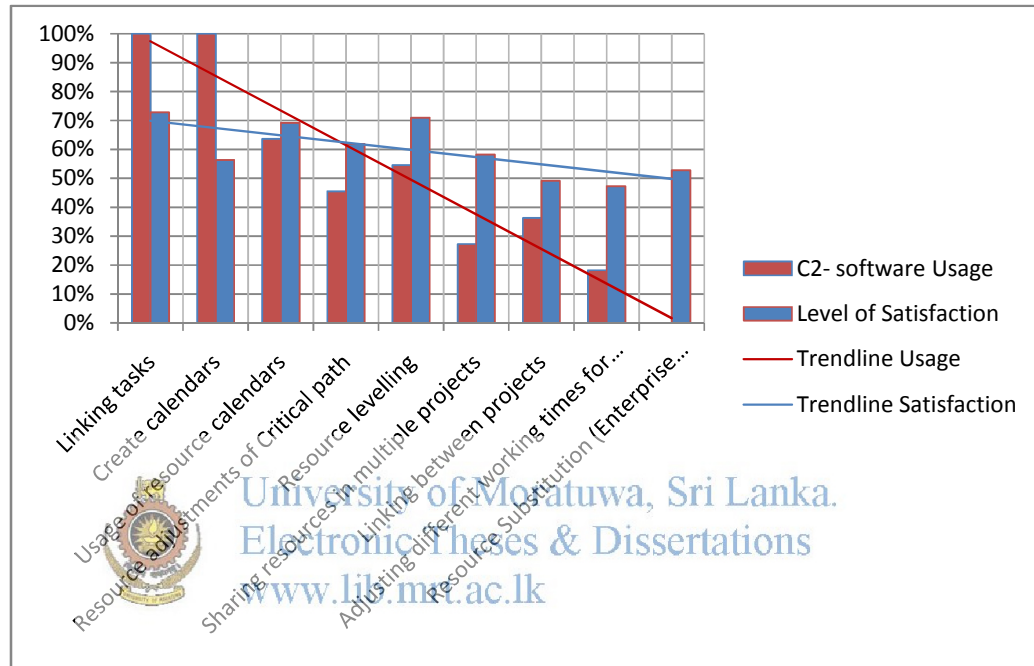


Figure 4.11: Extent of Software usage for Scheduling Vs level of satisfaction in particular activities (C2)

Dependency of activities through linking of tasks shows an average satisfaction above 70% while the usage of software for linking tasks by C2 firms show 100% figure. Even though the usages of software were below 50% or almost the same, the following activities were considered as 60% or higher in satisfaction. Only two activities go down 50% limit.

<u>Activity</u>	<u>Usage (%)</u>	<u>Satisfaction (%)</u>
Resource adjustments of Critical path	45%	62%
Resource levelling	55%	71%
Sharing resources in multiple projects	27%	58%
Linking between projects	36%	49%
Adjusting different working times for resources	0%	47%

C3 firms

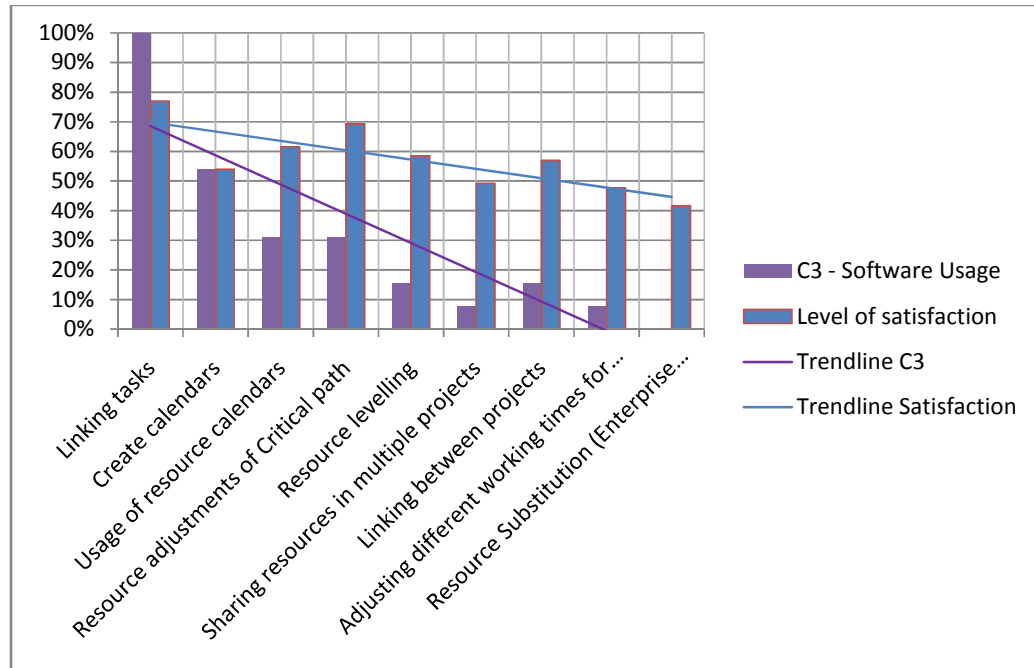


Figure 4.12: Extent of Software usage for Scheduling Vs level of satisfaction in particular activities (C3)

Comparatively lower software usage for scheduling activities by C3 firms than C1 and C2 category. They use software basically for linking the tasks which shows 100% usage & all other activities were below 30% usage except *create calendars* activity. Average 50% satisfactions of scheduling activities were expressed by them irrespective of software usage.

C4 firms

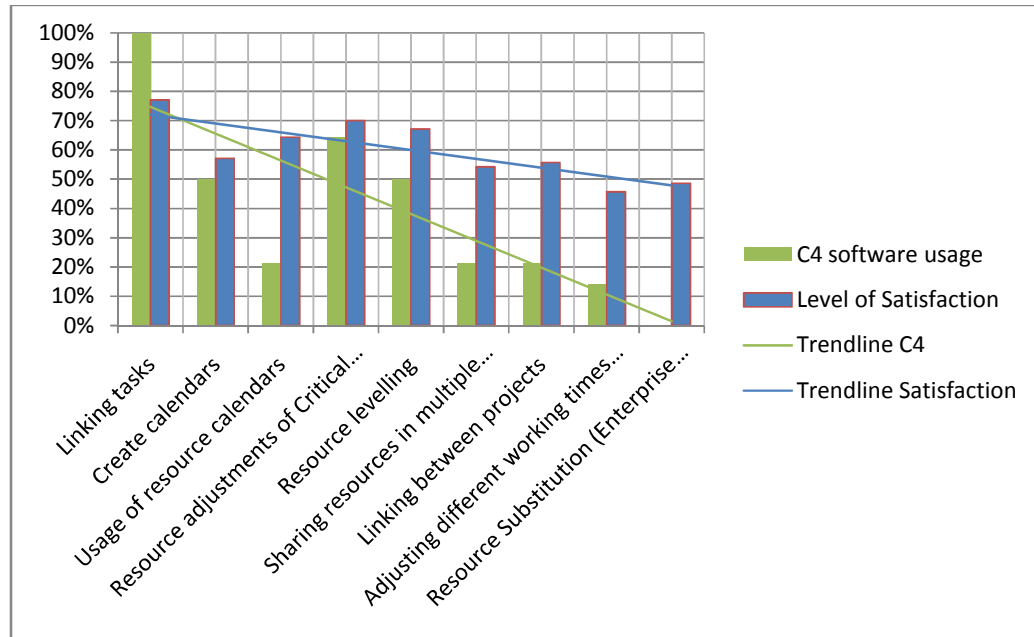


Figure 4.13: Extent of Software usage for Scheduling Vs level of satisfaction in particular activities (C4)

Only the activities *linking tasks* and *resource adjustment of critical path* showed a usage above 50% & all other activities were below 50% for C4 firms. Very less usage of software for *sharing resources in multiple projects*, *linking between projects*, *adjusting different working times for resources* activities by C4 firms, but with nearly 50% satisfaction level of each activity.

4.6 Monitoring & Controlling

C1 and C2 firms

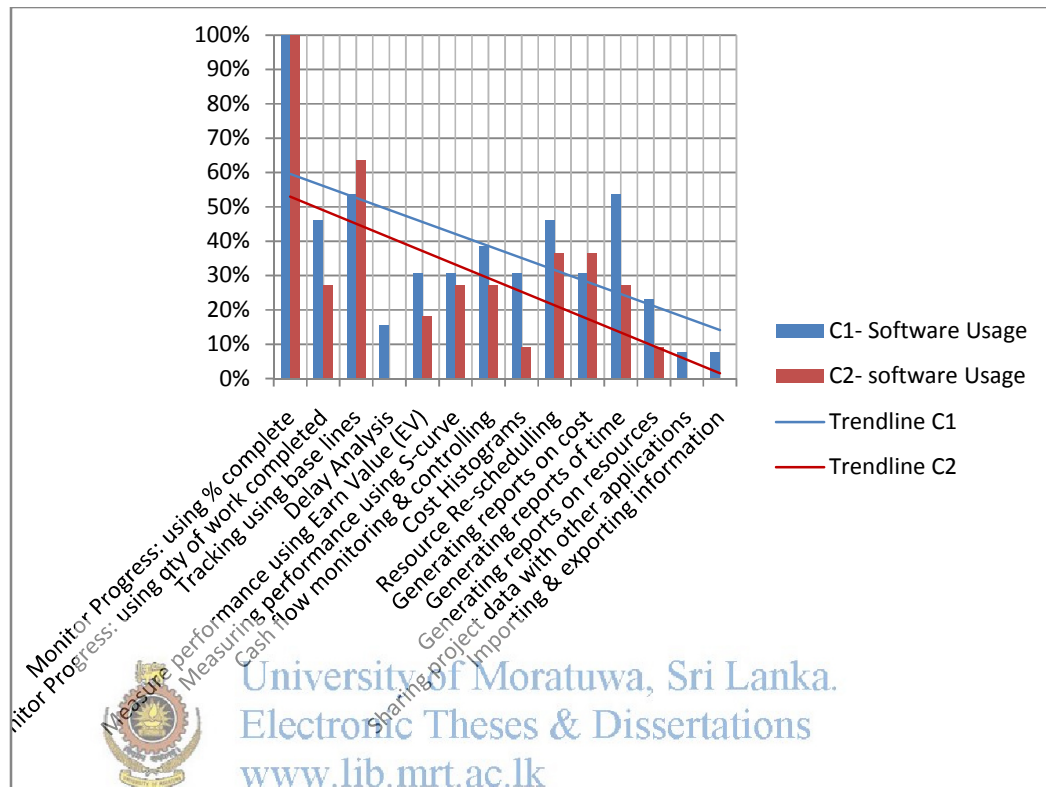


Figure 4.14: Extent of Software usage for Monitoring & Controlling (C1 & C2)

All the C1 & C2 firms used to get the progress figures of their projects through entering the percentage values of work items completed for their monitoring & controlling process. More accurate version to get the extent of completion, 46% of C1 & 27% of C2 companies use entering quantity of work done to the program to get overall completion of the project. One of the most important activities to track the project throughout its entire execution, *tracking using base lines*, that is assigning a baseline during planning stage & take it as reference to monitor the progress, was only applied by 54% of C1 & 64% of C2 firms.

Usage of software for *cash flow monitoring & controlling*, *measuring performance using S-curve* were below 38% for C1 firms & below 27% for C2 firms. Usage of earn value techniques to measure performance were 31% for C1 firms & 18% for C2 firms. This was comparatively a lower usage, as the C1 & C2 are the leading categories in the industry.

The generating reports through project management software were as follows for both firms;

<u>Activity</u>	<u>Software Usage (%)</u>	
	<u>C1</u>	<u>C2</u>
Generating reports on cost	31%	36%
Generating reports of time	54%	27%
Generating reports on resources	23%	9%

C3& C4 firms

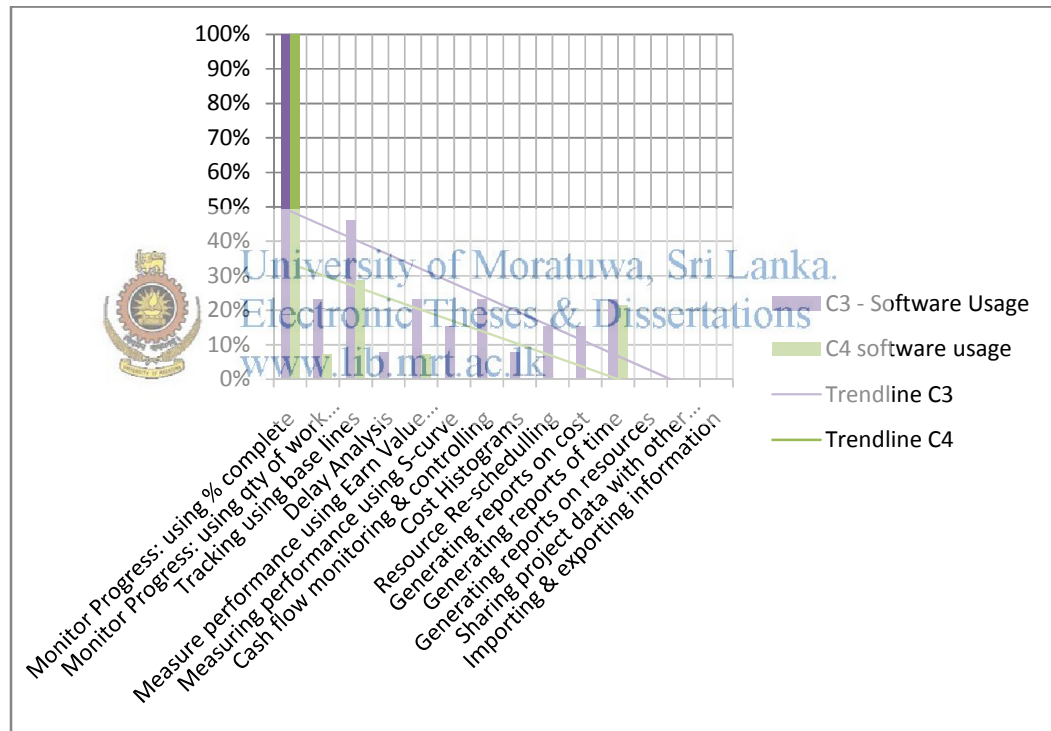


Figure 4.15: Extent of Software usage for Monitoring & Controlling (C3 & C4)

The usage figures of C3 & C4 firms were at a minimum level as shown in the above graph. Except the item monitor progress using percentate complete, all the activities were below 50% level & most of them were even below 25% usage level.

The usage & satisfaction figures calculated through this research for all four categories of firms are tabulated below:

#	Activity Description	% usage of PM software				Level of satisfaction (%)			
		C1	C2	C3	C4	C1	C2	C3	C4
1	Monitor Progress: using % complete	100 %	100 %	100 %	100 %	62 %	71 %	71 %	70 %
2	Monitor Progress: using qty of work completed	46 %	27 %	23 %	7% %	57 %	51 %	54 %	46 %
3	Tracking using base lines	54 %	64 %	46 %	29 %	63 %	67 %	65 %	51 %
4	Delay Analysis	15 %	0% %	8% %	0% %	38 %	33 %	23 %	27 %
5	Measure performance using Earn Value (EV)	31 %	18 %	23 %	7% %	62 %	35 %	58 %	37 %
6	Measuring performance using S-curve	31 %	27 %	15 %	0% %	60 %	35 %	49 %	26 %
7	Cash flow monitoring & controlling	38 %	27 %	23 %	0% %	65 %	60 %	57 %	54 %
8	Cost Histograms	31 %	9% %	8% %	0% %	49 %	33 %	31 %	23 %
9	Resource Re-scheduling	46 %	36 %	15 %	0% %	63 %	53 %	48 %	26 %
10	Generating reports on cost	31 %	36 %	15 %	0% %	52 %	44 %	46 %	43 %
11	Generating reports of time	54 %	27 %	23 %	21 %	63 %	62 %	55 %	61 %
12	Generating reports on resources	23 %	9% %	0% %	0% %	42 %	40 %	31 %	23 %
13	Sharing project data with other applications	8% %	0% %	6% %	0% %	26 %	27 %	20 %	20 %
14	Importing & exporting information	8% %	0% %	6% %	0% %	28 %	20 %	22 %	20 %

Table 4.8: Summary of usage of PM software & level of satisfaction

Level of Satisfaction

C1 firms

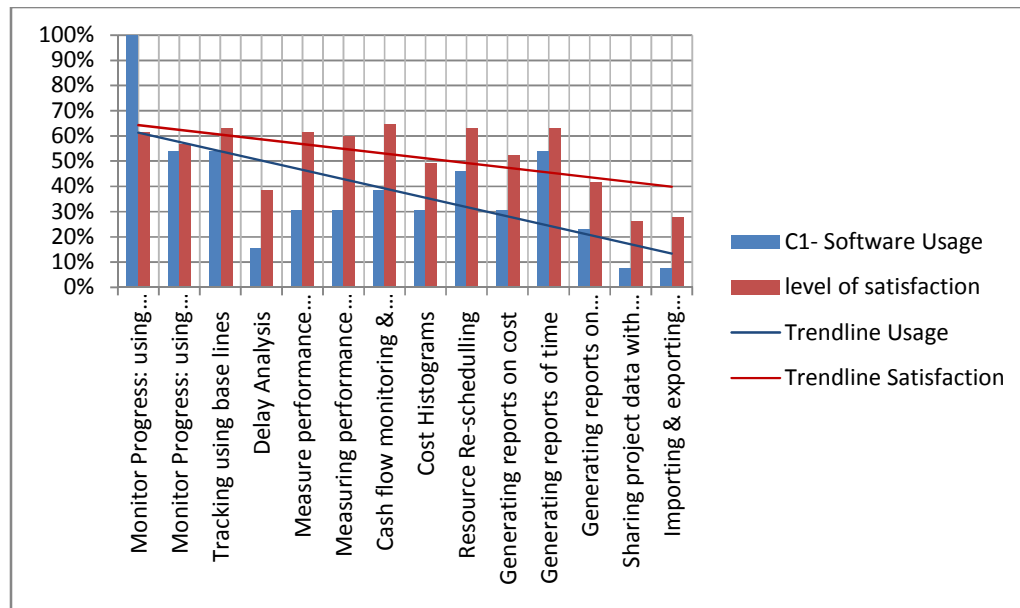


Figure 4.16: Extent of Software usage for Monitoring & Controlling Vs level of satisfaction in particular activities (C1)

C2 firms

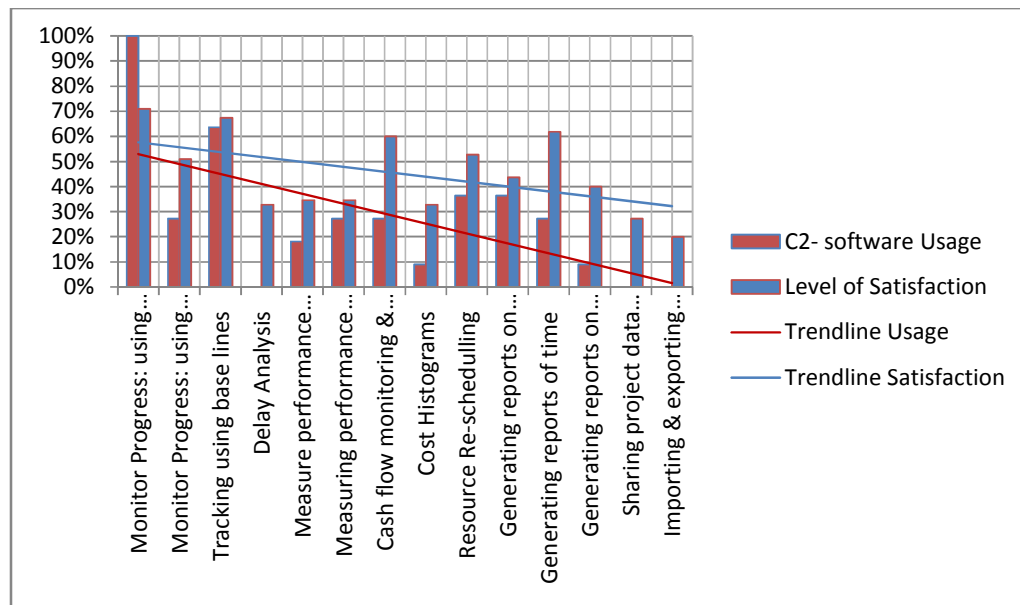


Figure 4.17: Extent of Software usage for Monitoring & Controlling Vs level of satisfaction in particular activities (C2)

C3 firms

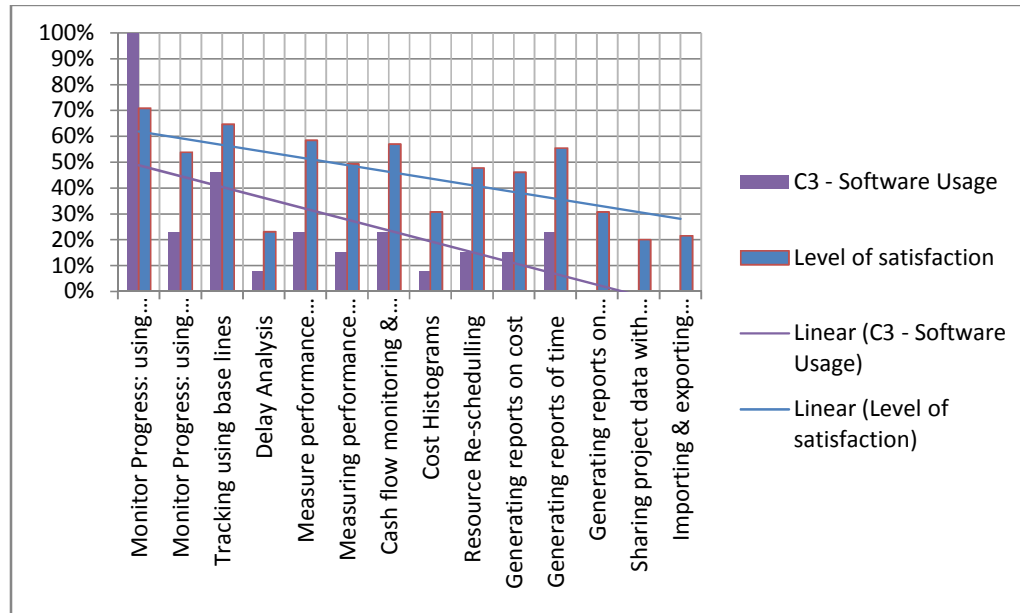


Figure 4.18: Extent of Software usage for Monitoring & Controlling Vs level of satisfaction in particular activities (C3)

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C4 firms

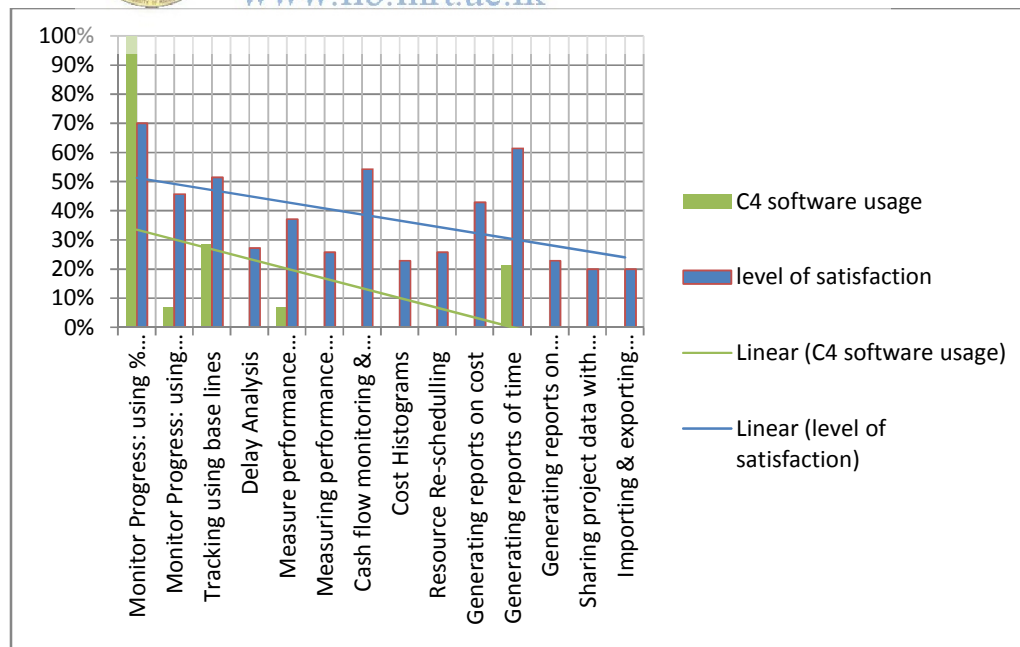


Figure 4.19: Extent of Software usage for Monitoring and Controlling Vs level of satisfaction in particular activities (C4)

4.7 User Satisfaction of Project Management Software Features

Time Management:

The satisfaction level of time management facilities available in project management software were measured through a scale provided in the questionnaire. The outcome is as follows;

Category	Satisfied	Not Satisfied
<i>C1</i>	92%	8%
<i>C2</i>	82%	18%
<i>C3</i>	92%	8%
<i>C4</i>	86%	14%

Table 4.9: Satisfaction with time management facilities

Further, the reasons for the satisfaction or non-satisfaction were taken in to consideration. Following the information & experienced gained in pilot survey & literature review, a list of reasons were included in the questionnaire, where a provision was also made to add if any other reason existed in firms, apart from the reasons mentioned.

The reasons mentioned for satisfaction of time management facilities are shown below;

Contribution factor	No of respondents				%
	C1	C2	C3	C4	
<i>Straight forward application</i>	4	1	4	3	27%
<i>Easy & Quick execution</i>	7	6	3	9	57%
<i>Technical support available</i>	1	1	4	0	14%
<i>Flexibility to various requirements</i>	0	1	0	0	2%

Table 4.10: Satisfaction indicators for time management facilities

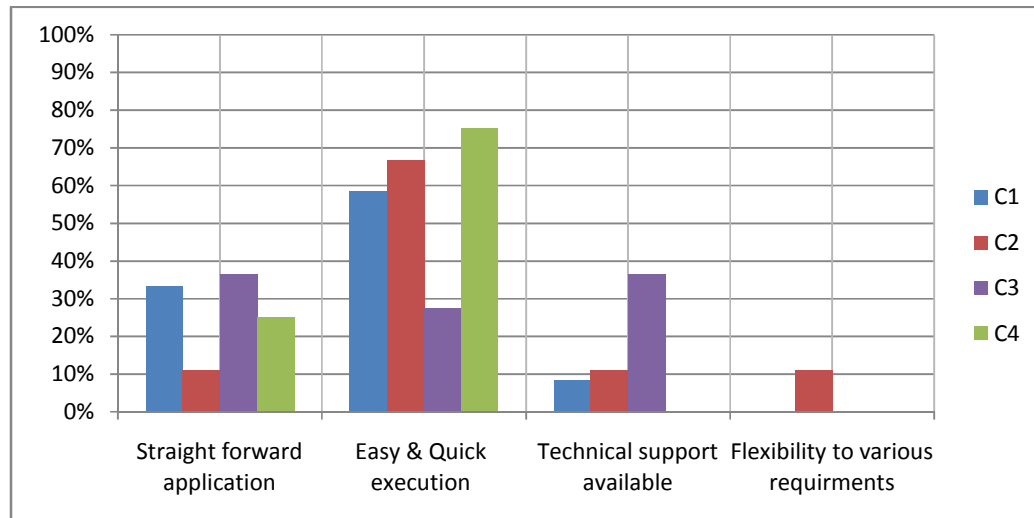


Figure 4.20: Responses for satisfaction of time management facilities

When consider all the construction firms subjected to this study, 57% (refer table 4.10) of sample has selected *Easy and Quick execution* as the 1st reason for satisfaction of time management facilities available. Straight forward application has been selected as 2nd most common reason for satisfaction, with 27% overall respond rate. C1, C2 & C3 firm's behaviour was also the same as described above. *Technical support available & straight forward applications* were the main reasons for their satisfaction on time management facilities of dedicated project management software.

One of the C2 firms had mentioned that, flexibility to various requirements of the organization in time management aspects of a project as the main reason for their satisfaction & mentioned it at the provision made to specify any other reasons than the options available in the questionnaire.

Among the firms, responded as they do not satisfy with the time management facilities available in software, 83% of firms indicated that, lack of experienced people with particular software as the main reason for their non-satisfaction. The rest of the firm's position was, the return from software usage was comparatively low & as a percentage, number of companies was 17% of non-satisfied firms.

All the C1, C2 and C3 firms and one C4 firm indicated the *lack of experienced people* as main reason while only one C4 firm said that *comparably low return from software usage* as their cause for non- satisfaction.

4.8 Difficulties faced by companies in usage of project management software

Some specific reasons were included in the questionnaire, which were abstracted & summarized from literature review, where it provided the interviewee to answer easily regarding the difficulties faced by their organization in using project management software. The responses are summarised in below table which include the number of responses by each category & overall percentage of each factor, considering all the firms subjected to this study. In addition, a graphical view presents the individual percentages of all four firms separately, of their difficulties faced, while using software.

Contribution factor	No of companies responded				%
	C1	C2	C3	C4	
<i>High cost</i>	2	2	2	1	14%
<i>Non availability of trained staff</i>	6	5	5	7	45%
<i>Lack of interest among top management</i>	2	2	6	5	31%
<i>Lack of interest among the staff involving in PM activities</i>	1	1	0	1	6%
<i>Fear of change to new systems from staff of long tenure</i>	1	1	0	0	4%

Table 4.11: Responses for difficulties faced by contractor firms

Considering all the firms subjected to this study, 39% of firms had mentioned *non availability of trained staff* as the main difficulty faced while using software for project management. *Lack of interest among top management* had become as the 2nd most influencing factor for contracting firms.

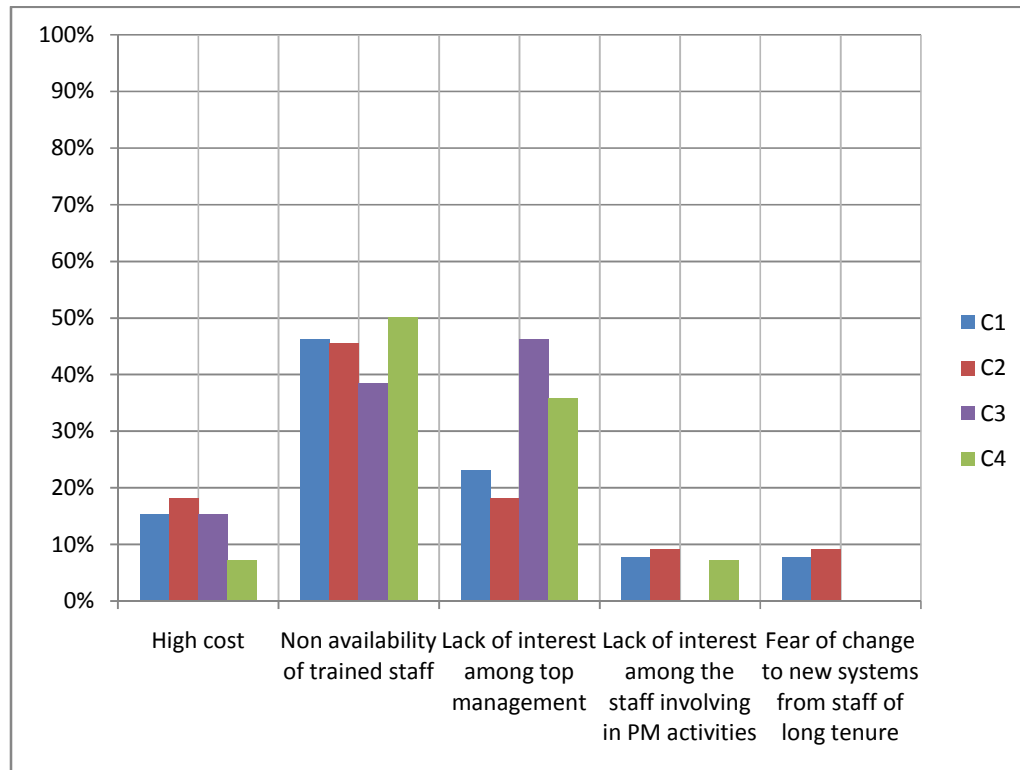


Figure 4.21 Responses for difficulties faced by contractor firms

Non availability of trained staff was marked as the difficulty faced by C1 firms to 1st place & *lack of interest among top management* has become the 2nd reason. *Lack of interest among the staff involving in project management activities & higher cost* were the next most influencing factor for C1 firms. A similar responses have been made by C2 & C4 firms as C1 and only C3 firms has mentioned *lack of interest among top management* as the most critical factor in their software usage.

4.9 Benefits gained using project management software

The results obtained through questionnaire survey were summarised & shown in the below table & graph. The table presents the number of responses & percentage figure for each reason, considering all the firms subjected to the study, irrespective of type of firm. The graph presents the individual respond rates of each type of firm, for the reasons mentioned as benefits gained through project management software usage.

Contribution factor	No of companies responded				%
	C1	C2	C3	C4	
<i>Easy for management & administration works</i>	9	9	6	10	67%
<i>Increase of profit margins</i>	1	0	2	0	6%
<i>Generating Quality reports</i>	2	2	5	2	22%
<i>Increase company reputation (image)</i>	1	0	0	2	6%

Table 4.12: Responses for benefits gained by contractor firms

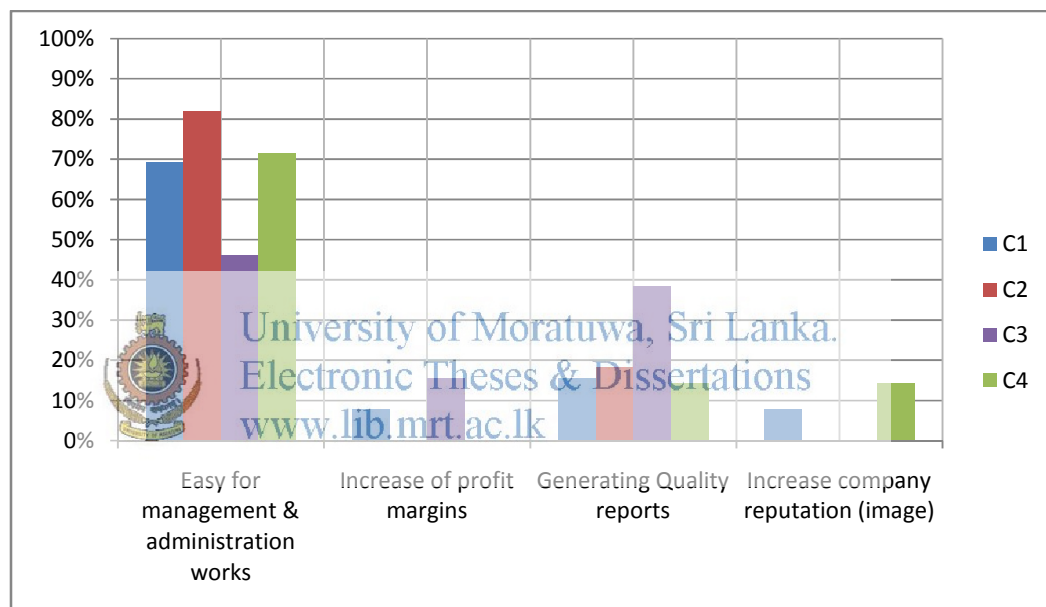


Figure 4.22: Responses for benefits gained by contractor firms:

All the firms have responded that *easy for management & administration works* at first place in benefits gained list, with overall percentage of 67%. This condition was similar for each individual firm as shown in the above graph. *Generating quality reports* has become to 2nd place in the list with 22% respond rate.

4.10 Future Development

In section 07 of the questionnaire, it was asked by all firms whether they have any plan of improving the project management software usage in the organization in future. The responses received are tabulated below. Only 33% of firms replied that

they have a plan for future improvement where rest of firms (67%) did not have any plan for future development in software usage for project management activities.

Type of firm	Future development plan available			
	Yes		No	
C1	5	38%	8	62%
C2	4	36%	7	64%
C3	4	31%	9	69%
C4	4	29%	10	71%
Total	17	33%	34	67%

Table 4.13: Availability of future development plan

Majority of firms have responded that they will trained their staff to make them capable of handling the software, to meet their business requirements in project management activities & it was 65% as a percentage. *Introducing latest versions* has become the 2nd most responded action as the future plan for development and as a figure, 28%.



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Method to be adopted	No of companies responded				%
	C1	C2	C3	C4	
<i>Introducing latest versions</i>	1	1	1	2.75	28%
<i>Introducing new software packages</i>	1	0	0	0	5%
<i>Recruiting trained people</i>	0	0	0	0.5	2%
<i>Training relevant staff</i>	3.5	4	4	2	65%
<i>Introducing company policies</i>	0	0	0	0	0%

Table 4.14: Future development in software usage for project management: methods

The following graph presents the individual components of each category of contractor firms for their future developments activities. This is a more detailed version of the above table.

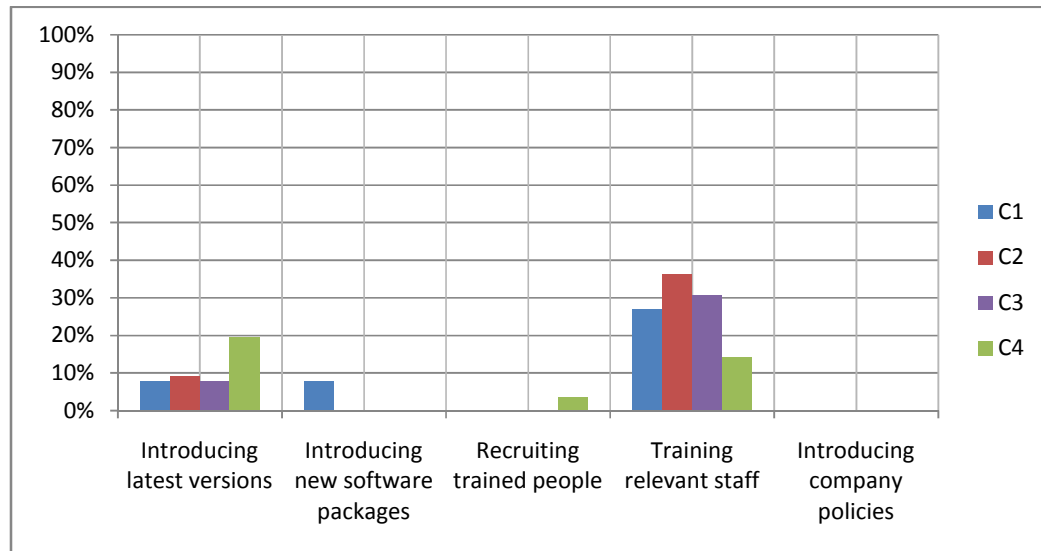


Figure 4.23: Future development actions by each category of contractor firms

4.11 Summary

The extent of software usage in construction project management by building contractor firms in Sri Lankan construction industry were analysed & presented in this chapter. Mainly the firms registered in ICTAD as building contractor firms of grades C1, C2, C3 & C4 were subjected for this analysis. The data were gathered through a questionnaire survey & analysed to get the extent of dedicated software usage for project management activities & the level of satisfaction of each PM activity, irrespective of software usage. The findings were presented in graphical, tabular & descriptive formats for easy understanding.

The building contractor firms use the initial planning techniques, such as creating work breakdown structure, find start, finish dates & durations etc of a project & use approximately by all firms, as per the results obtained through questionnaire survey. The usage of software to find critical path, critical activities, assigning base line for planning were not fully used & the usage was around 50% of the firms, subjected to study. Construction firms subjected to study have shown very less concern for monitoring & controlling functions available in the project management software. Only the firms C1 & C2 showed considerable usage of software facility for report

generation, cash flow monitoring & controlling, measuring performance using S curve etc, rest of firms are with less usage of facilities available in software.

Non availability of trained staff has become the most significant reason, appeared as difficulty faced by the construction firms of usage of dedicated project management software. Only around 35% of construction firms in the industry have a plan to develop their software systems in future to facilitate the project management requirements. The rest, 65% does not have any plan of improving their systems. Easy management & administration activities and generating quality reports through the software within short period of time has become most attractive reasons under benefits gained through software usage by contractor firms.

The graphical views in each stage show a pattern of decreasing the usage of software facilities by firms, along with the complexity of management activities.



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5. CONCLUSIONS & RECOMMENDATIONS

5.2 Conclusions

- a) The first objective of the research was to find out to what extent the project management software are being used in the construction industry for their planning, scheduling and monitoring / controlling activities. The building contractor firms use the initial planning techniques, such as creating work breakdown structure, to find start, finish dates & durations etc of a project & use approximately by all firms, as per the results obtained through questionnaire survey. The usage of software to find critical path, critical activities, assigning base line for planning were not fully used & the usage was around 50% of the firms, subjected to study. Usage for cash forecasting, resource planning & allocation, planning multiple projects were at a minimum level, of the industry. Only fractions, approximately less than half of the facilities available in PM software for planning activities were utilized by construction companies in their planning of projects.
- b) Scheduling activities were also used by firms fully in the area of linking tasks, but gradually decreases with the density of the activities. Creating calendars for project, resource calendars were used average 70% by C1 & C2 firms, but very less use by other type of firms in the industry. Utilization of software for resource levelling, sharing resources in multiple projects, adjusting different working times for resources was below 50% for all firms in the construction industry & even below 20% for C3 & C4 category firms. Even though most of the firms handling several projects simultaneously, the facility *linking between projects* were hardly used by the construction firms & limited only to C1 & C2 category.
- c) Construction firms subjected to study have shown very less concern for monitoring & controlling functions available in the project management software. Only the firms C1 & C2 showed considerable usage of software facility for report generation, cash flow monitoring & controlling, measuring performance using S curve etc, rest of firms are with less usage of facilities available in software. Still some traditional methods, using ordinary software

are being used in the industry to manage such monitoring & controlling tasks. One of the reason for less usage of these monitor & control facilities is since the construction firms do only the basic activities in planning & scheduling stages & avoid utilizing middle & more detailed parts of the software features where it will lead to lack of information available in latter stages for a proper monitoring & controlling mechanism.

- d) Through the satisfaction indicators, a pattern can be identified that, high level of satisfaction has been reached by all firms when the software usage for that particular area was high. Even without software, medium level (around 60% satisfaction in the scale used) can be achieved for most of the activities, but possibility is there to increase the efficiency of activities through software usage & as a result, to gain an increase in profit.
- e) The usage of software for cash forecasting/ controlling, resource planning & controlling are poor in Sri Lankan building construction industry. Lack of experienced staff & less interest from higher management may be the reasons for this situation, but this will lead to unnecessary losses in both financial & other resources, especially of a construction project due to this matter.
- f) The building construction firms are using project management software for their projects mainly since the facility provide easy administration of works, integration & approach to repetitive tasks. One important finding of this study was the contractor firms have mentioned that, *force due to competitors, project teams & consultants* as the second most important factor for usage of project management software.
- g) Non availability of trained staff has become the most significant reason, appeared as difficulty faced by the construction firms of usage of dedicated project management software. Though most of their staff has some basic knowledge over the software, going deeper & handling latest facilities are not possible. Lack of interest among top management of utilizing latest project management software within their companies has become the second most responded reason, as the difficulties faced.
- h) Easy management & administration activities & generating quality reports through the software within short period of time has become most attractive

reasons under benefits gained through software usage by contractor firms. There were very few responds to the *increase profit margins & increase company reputation* through the usage of dedicated software for project management.

- i) Only around 35% of construction firms in the industry have a plan to develop their software systems in future to facilitate the project management activities. The rest, 65% does not have any plan of improving their systems. Among the firms who have a plan to develop the usage of project management software, getting trained the staff has become the 1st place activity, mentioned by firms as future development area. As a percentage, it was 65% of the companies who have a future plan to develop their software usage. A 28% of firms in a place to introduce latest/ newer versions of software to their firms, to enhance the productivity & efficiency.

5.3 Recommendations

The following recommendations are based on the results obtained through the study conducted among building contractors in the industry:

- a) The contractor firms should conduct a self study to identify the areas where they can increase the usage of software & take measures to utilize the software more than what they do at the moment.
- b) Since the “lack of interest among top management” has become the second most responded reason for difficulties faced by firms, of using PM software an awareness programs can be arranged to senior staff of firms where the higher management of firms have the opportunity to understand the importance of usage of dedicated software for project management, what are the benefits they can gain, how the loses can be minimized through managing activities using software.
- c) Relevant staffs who have engaged in project management activities in the construction firms to be trained to get the maximum usage of the available software facilities, since there is a clear shortage in the industry of trained staff. This can be arranged individually by contractor firms and through the

relevant engineering institutions where they also have certain responsibilities to train the people to cover up this gap in the industry.

- d) The contractor firms should concern more to utilize the software facilities available over the cash & resource management areas while managing projects. Currently the attitude of firms is to use only the basic features of software, just to initiate the plans & schedules, but not to create a plan which will enable proper monitoring & controlling base in the execution stage. The recommendations made in previous section (C) will provide the basis to initiate the expanding since the relevant staff will get training.

5.4 Recommendations for Future Research

- a) A general overview of the concern objectives were resulted from the study since it was spread among large number of contractor firms, several areas of PM activities in planning, scheduling and monitoring & controlling. Conducting a study in future with case study basis will provide the researcher to study the results obtained from this research further & investigate in depth and with meticulous attention to each and every fact.
- b) Narrow down the study area only to Cost & Resource aspects of project management will facilitate future researcher to investigate further on the usage & areas of usage to be improved in construction industry since one of the conclude of this study was that the usage of PM software for cost & resource managing in the industry is comparatively low.
- c) Similar study conduct among engineering consultancy firms will provide the basis to compare where the consultants & contractors in the industry stands in dedicated project management software usage & can seek a solution to fill the industry shortage of trained staff through the involvement of experts in consultancy firms (conducting training/ workshops etc).

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1.0 Questionnaire format

QUESTIONNAIRE

(Survey to find out how effective the usage of Project Management Software in Sri Lankan Building Construction Industry)

Notes:

1. It will take only avg. 20 minutes time to fill up this questionnaire.
2. The questionnaire have to be answered in the following ways,
 - (1) Yes / No (ticking or underline)
 - (2) Ticking on alternatives
 - (3) Word answers
 - (4) Answers to be marked on a scale
3. Please add remarks where useful to expand answers.
4. Information obtained in this questionnaire will be used collectively with other responds.
5. This questionnaire is consisting of mainly seven sections, 18 nos questions to be answered.

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Section 01
General Organizational Information
 Name of Organization (not compulsory) :

1) ICTAD grading:

New category (pervious grading)

- | | | |
|----|---|----------------------|
| C1 | (M1) | <input type="text"/> |
| C2 | (M1) | <input type="text"/> |
| C3 | (M3, 150 ≥ X ≥ 100 million finance limit) | <input type="text"/> |
| C4 | (M3, 100 ≥ X ≥ 50 million finance limit) | <input type="text"/> |

2) No of building projects handling simultaneously (average) by the organization

≤2 betⁿ 3 & 4 betⁿ 5 & 6 betⁿ 7 & 8 9≤

3) No of Planning Engineers or Qualified project planners working in the organization?

Nos

4) Average Project completion as scheduled % (percentage)

Section 02

Software Usage for Project Management: General (PM software, office packages, data bases etc...)

5) How long the company has been using software for Project management?

☐ 0-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16-20 years ☐ 20< years

6) Reasons for using software for Project Management (if more than one, put them in priority order)

Easy Administration works, Integration & approach to repetitive tasks ☐

Standardizing company formats ☐

Forced due to Competitors, Project teams, consultants ☐

To reduce cost ☐

Desire to keep up to date with development ☐

Other (please specify)

Section 03

7) Usage of Dedicated Project Management Software

MS Project ☐

MS Project Server ☐

Primavera Project Planner ☐

Other (PM software, database, Office packages etc)

Scale to be used:

1: none	2: poor	3: average	4: good	5: Excellent
---------	---------	------------	---------	--------------

Activity Description

Software Usage

the Quality of Output

(Not depends on Software usage)

8) For **Planning**

To find start/finish/durations	☐ Yes / ☐ No	1	2	3	4	5
To find floats of activities	☐ Yes / ☐ No	1	2	3	4	5
Create WBS/OBS	☐ Yes / ☐ No	1	2	3	4	5
To find critical path	☐ Yes / ☐ No	1	2	3	4	5
To find critical activities	☐ Yes / ☐ No	1	2	3	4	5
To check alternative techniques & methods	☐ Yes / ☐ No	1	2	3	4	5
Resource allocation for tasks	☐ Yes / ☐ No	1	2	3	4	5
Resource planning	☐ Yes / ☐ No	1	2	3	4	5
Assigning Base line for planning	☐ Yes / ☐ No	1	2	3	4	5
Assign responsibilities	☐ Yes / ☐ No	1	2	3	4	5
Cash flow forecasting	☐ Yes / ☐ No	1	2	3	4	5
Enterprise Resource pool	☐ Yes / ☐ No	1	2	3	4	5
Planning multiple projects	☐ Yes / ☐ No	1	2	3	4	5

9) Scheduling

Linking tasks (dependency)	☐ Yes / ☐ No	1	2	3	4	5
Linking between projects	☐ Yes / ☐ No	1	2	3	4	5
Create calendars	☐ Yes / ☐ No	1	2	3	4	5
Usage of resource calendars	☐ Yes / ☐ No	1	2	3	4	5
Resource adjustments of Critical path	☐ Yes / ☐ No	1	2	3	4	5
Resource leveling	☐ Yes / ☐ No	1	2	3	4	5
Sharing resource in multiple projects	☐ Yes / ☐ No	1	2	3	4	5
Adjusting different working times for resources	☐ Yes / ☐ No	1	2	3	4	5
Resource substitution (Enterprise projects)	☐ Yes / ☐ No	1	2	3	4	5

10) Monitoring & Controlling

Monitor progress: using % complete	☐ Yes / ☐ No	1	2	3	4	5
Monitor progress: using qty of work completed	☐ Yes / ☐ No	1	2	3	4	5
To check alternative techniques	☐ Yes / ☐ No	1	2	3	4	5
Tracking using Base Lines (using actual dates)	☐ Yes / ☐ No	1	2	3	4	5
Delay analysis	☐ Yes / ☐ No	1	2	3	4	5
Measuring performance using Earn Value (EV)	☐ Yes / ☐ No	1	2	3	4	5
Measuring performance using S-Curve						
Cash flow monitoring & controlling	☐ Yes / ☐ No	1	2	3	4	5
Cost Histograms	☐ Yes / ☐ No	1	2	3	4	5
Resource re-Scheduling	☐ Yes / ☐ No	1	2	3	4	5
Generating reports on cost (EV, Cash flow, Budget, Over budget etc)	☐ Yes / ☐ No	1	2	3	4	5
Generating reports on time (Started works, completed works, not started works etc)	☐ Yes / ☐ No	1	2	3	4	5
Generating reports on resources	☐ Yes / ☐ No	1	2	3	4	5
Sharing project data with other Applications (ex: cash flow in Excel)	☐ Yes / ☐ No	1	2	3	4	5
Importing & Exporting Information	☐ Yes / ☐ No	1	2	3	4	5

Section 4

User Satisfaction

- 11) Satisfaction level for **Time management** facility available in Project Management software:

Scale: ☐1 ☐2 ☐3 ☐4 ☐5

- 12) If satisfied, Contributing factors for satisfaction (if more than one, put them in priority order)

Straight forward application ☐

Easy & Quick execution ☐

Technical support available ☐

Other (please specify)

- 13) If Not satisfied, Contributing factors (if more than one, put them in priority order)

Comparably low return from software usage ☐

Available software does not fulfil the needs ☐

Insufficient time for planning ☐

Lack of experienced people with software ☐

Other (please specify)

- 14) Satisfaction level for **Cost management** facility available in Project Management

software:

Scale: ☐1 ☐2 ☐3 ☐4 ☐5

- 15) Satisfaction level for **Resource management** facility available in Project Management software:

Scale: ☐1 ☐2 ☐3 ☐4 ☐5

Section 05

Difficulties faced

- 16) What are the difficulties faced by Organization of using PM Software? (if more than one, put them in priority order)

High cost ☐

Non availability of trained staff ☐

Lack of interest among top management ☐

Lack of interest among the staff involving in PM activities ☐

Fear of change to new systems from staff of long tenure ☐

Section 06

Benefits gained

17) What are the benefits gained using PM software? (if more than one, put them in priority order)

Easy for management & Administration activities	☐
Increase of profit margins	☐
Generating Quality reports	☐
Increase company reputation (image)	☐

Section 07

Future Development

18) Any plan of expanding Project Management Software usage within the organization?

Yes ☐ No ☐

19) If yes, how? (If more than one, put them in priority order)

Introducing latest versions	☐
Introducing new software packages	☐
Recruiting trained people	☐
Training relevant staff	☐
Introducing company policies (ex: software usage is a must)	☐
Other (please specify)	



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