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THESIS

STUDY AND EVALUATION OF CONSTRUCTION PERFORMANCE FOR MASS HOUSING FOR LOW INCOME GROUP IN BHUTAN

CHANE ZANGMO

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
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Over the last decade, Bhutan has experienced a very rapid pace of urbanization. The overall socio-economic development in the country and rapid growth of Bhutan's urban centres has placed unprecedented pressure on the existing urban housing including urban infrastructures. The provision of housing for the low income group was approved in 1998-1999, and construction started in February 2001. The Changjiji Project, Thimphu was executed in three phases, with the total cost of Nu. 470 million ($1 = Nu. 48). The District Housing Projects commenced in May 2005 and the total cost was Nu. 319 million. The implementing agency is the National Housing Development Corporation. The Changjiji housing consists of 676 units and 48 shops, and the District Housing 306 units spread over seven Districts and two Sub Districts. In an attempt to recommend approaches for improving the construction management system in provision of mass housing, the current practice of management was studied through personal interviews, questionnaires and document reviews. The respondents were the site engineers, project engineers, the project managers and general manager from the owner side. The various problems faced and the causes leading to the problems have been identified. The present management system is then compared with the standard management practices, to arrive at the management solutions for mass housing in Bhutan.

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Student's signature Thesis Advisor's signature

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STUDY AND EVALUATION OF CONSTRUCTION PERFORMANCE FOR MASS HOUSING FOR LOW INCOME GROUP IN BHUTAN

INTRODUCTION

The Kingdom of Bhutan is a landlocked Nation in South Asia with total area of 38,394 square kilometers, bordered by China in the north and India in the south. The landscape ranges from subtropical plains in the south to the Himalayan heights in the north, with some peaks exceeding 7,000 meters (23,000 feet) above sea level. The population of the country was estimated at 634,982 in 2005. After centuries of direct monarchic rule, Bhutan held its first democratic elections in March 2008. Figure 1 shows the map of Bhutan.

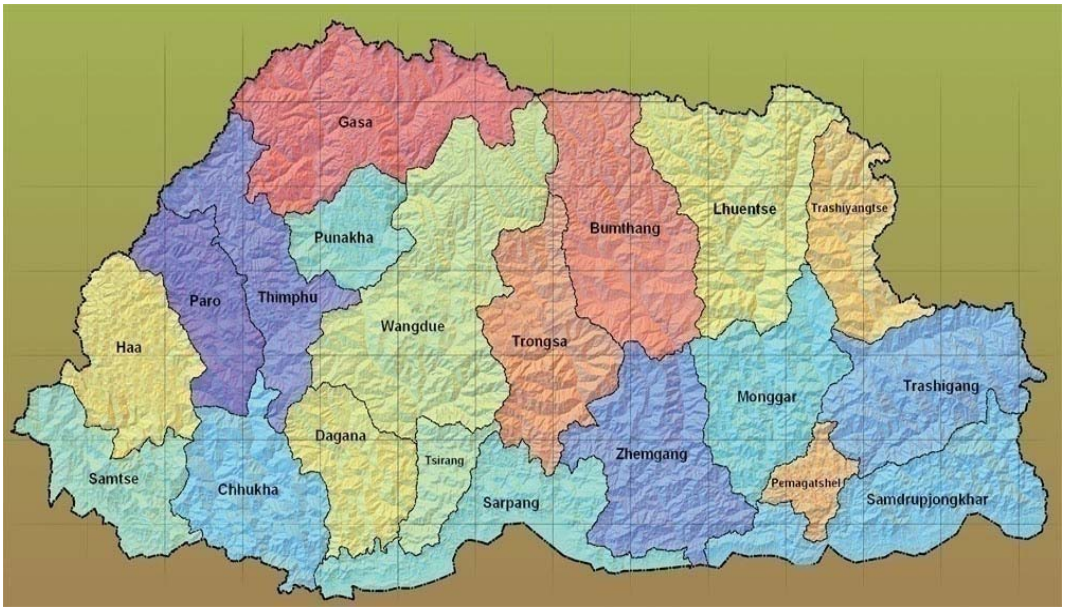


Figure 1 Map of Bhutan

Bhutan started her development process in 1961 with the inception of the first five year plan (FYP), when the country opened its doors to the forces of change and modernization. The first major project undertaken was the construction of a road from Phuentsholing (Indian border town) to the capital, Thimphu. Thereafter, numerous construction projects have been undertaken especially with financial and technical support from the Government of India (GOI) in the subsequent Five Year Plan periods. Other Developmental partners providing financial and technical assistance are the Swiss Development Corporation (SDC), Japan International Cooperation Agency (JICA), the World Bank (WB), and the Asian Development Bank (ADB).

In all the Five Year Plans, infrastructure development involving construction of buildings, roads, bridges, water supply and irrigation canals etc., has formed the major capital investment of the government. As much as the growth and changes have taken place in the provision of the infrastructure facilities, so has the organization that has been vested with this responsibility.

The first organization formed in 1961 to look after the construction was called Bhutan Engineering Services, which in 1966 was renamed the Public Works Department (PWD). The public works Department, initially under the Ministry of Development and later under Ministry of Social Services was the main builder of infrastructure pertaining to both rural and urban settlements. Later, the organization was put under the Ministry of Communications (www.mowhs.gov.bt)

During the re-structuring of the Royal Government, in 1999, a number of recommendations emerged. One recommendation was to restructure the Ministry of Communications and a new Ministry for Construction established. Accordingly, the Ministry of Works and Human Settlement was established in 2003. Figure 2 shows the organogram of the Ministry of Works and Human settlement.

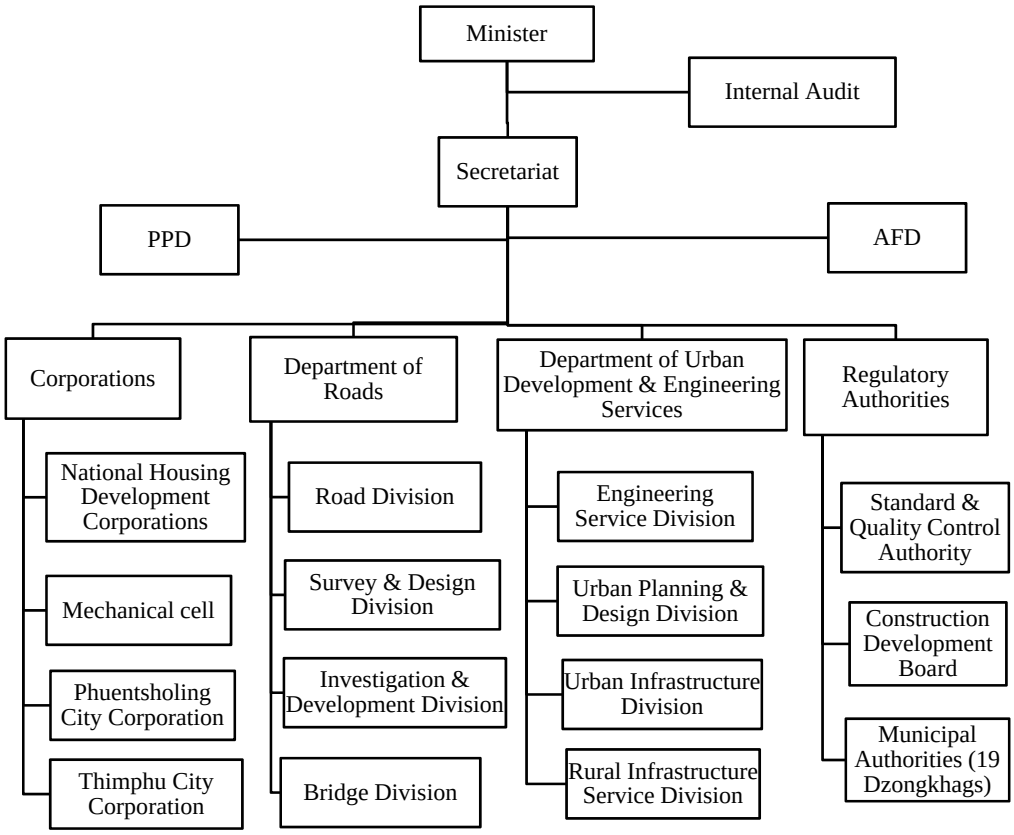


Figure 2 Organogram of the Ministry of Works and Human Settlement

Over the last decade, Bhutan has experienced a very rapid pace of urbanization. Additionally, with current levels of rural-urban migration, urban populations are projected to rise to around half of the total population by 2020 (Draft Tenth Plan). This has already placed enormous pressures on the two major cities of Thimphu and Phuentsholing and some of the larger towns around the country. Urban centers are already experiencing the adverse effects of urbanization such as housing scarcity, water shortages, sanitation and waste disposal problems. Ensuring affordable housing is a critical urban issue in Bhutan.

Housing shortage for the low income group, defined as those earning between Nu. 3000-5000 per month, is another indication of urbanization (Ninth Plan Main Document). This income group spends about 15-20% of their salaries on house rent.

The overall socio-economic development in the country and rapid growth of Bhutan's urban centers has placed unprecedented pressure on the existing urban housing including urban infrastructures, especially for the lower income group. Studies carried out in 1999 indicated the requirement of 3892 units in Thimphu for the five year period 2000-2005 (4th Engineering Conference, May 2007).

The involvement of the private sector in the housing sector is generally restricted to commercially viable areas and more often than not, housing for lower income groups is seen as an unattractive investment. Therefore, it has become increasingly apparent that the government will have to continue providing housing for economically weaker sections of the society for sometimes to come.

Low cost rental units owned by the Royal Insurance Corporation of Bhutan and National Pension and Provident Fund Bureau are few in numbers compared to the demand, and due to a low return on investment and lack of land availability, the corporations have not undertaken additional major housing development programs. Housing owned by the Royal Government and rented to its employees were also short of demand.

Provision of housing for the low income group was approved in 1998-1999. The design and land acquisition was carried out in 1999-2000, and the construction of the 1st phase started in February 2001. The project was executed in three phases. The total cost of the project was Nu. 470 million ($1 = Nu. 48) including the site development and infrastructure works, and is fully funded by the Royal Government of Bhutan. The District Housing Projects commenced in May 2005 and was completed in June 2008 and

the total cost was Nu. 319 million. It was funded by the Government of India. The implementing agency was the Department of Urban Development and Engineering Services, which was later transferred to the National Housing Development Corporation.

To mitigate, co-ordinate and implement overall housing programs in the country and in particular to provide housing for the lower income group, the Royal Government of Bhutan approved the establishment of National Housing Development Corporation (NHDC) in September 2003 as central apex body responsible for housing activities in the country with the following main objectives (www.nhdc.gov.bt)

- To provide safe, basic & affordable housing;
- To promote home ownership and;
- To create a transparent and well functioning housing market.

The National Housing Development Corporation has completed low income housing construction of 676 units in Thimphu, and 306 units spread over 7 Districts and two sub districts, the details of which are given below in table 1 and table 2

Table 1 Details of housing for low income group at Changjiji.

Sl No	Phase	Number of Bldgs.	Units per Bldg.	Total units
1	Phase I	10	12	120
2	Phase II			
	Type I	24	12	288
	Type II	20	9	180
3	Phase III			
	Type I(B)	5	8	40
	Type III	12	4 units and 4 shops	48 units and 48 shops
	Total	**71**		**676 units and 48 shops**

Table 2 Details of the housing for low income group in the various districts.

Sl No	District/sub districts	Number of Bldgs.	Units per Bldg.	Total units
1	Trongsa	4	6	24
2	Shemgang	6	6	36
3	Dagana	6	6	36
4	Lhuntse	5	6	30
5	Tashigang	10	6	60
6	Tashi Yangtse	6	4	24
7	Samdrup Jongkhar	9	6	54
8	Bangtar	4	6	24
9	Diapham	3	6	18
	Total	**53**		**306**

Statement of the Problem

While execution of the housing projects by the NHDC, following problems have been faced specifically in the changjiji housing complex at Thimphu.

The housing project was delayed beyond the scheduled completion time ranging from few days to more than a year. The changjiji housing project supposedly to be completed by June 2006 was completed only in September 2007, with some infrastructure works yet to be completed.

Kinley *et al.* (2007) in his research on Project Performance of Bhutan Building Construction had found out that 54% of the school building, 31% of residential and 43% of the office buildings were delayed beyond the scheduled date of completion, and 71%, 31% and 57% of the school, residential and office building construction projects respectively had suffered from cost overruns. It was however found that the project time performance of the residential building projects are better than the school and office projects, because of the functional requirements of the school and office buildings being dictated by its usage and size of organization.

The designs of the buildings were done without consideration of the site condition/terrain which led to increase in the total construction cost over the contracted amount.

Most of the buildings built especially in Phase I, changjiji have problems associated with quality. Bringing improvement in the quality of construction is still a major challenge faced. The NHDC had to provide extended quality supervision although the contractors are morally and contractually bound to supervise and deliver quality products as per the contract agreements. Therefore extensive time and resources were spent in preventing/rectifying poor quality of construction and contractual deviation.

As per the objective of the Government to encourage the use of local materials and local industries, prefabricated roof tiles were used for phase I and II, which has led to numerous roof leakage problems and also additional cost for the wooden roof truss. The prefabricated door and window structures which were supplied by the Government as per

the contract agreement could not be supplied on time leading to delays, and also the water supply problem was created mainly due to the use of local made HDPE pipes for external water supply.

The construction works are carried out by foreign semiskilled or unskilled laborers on labor contract which had a direct consequence on the quality of the constructions. This process has been encouraged on one hand by economic reasons and on the other, for lack of ready supply of workforce within the Country. In the absence of any certification procedures for the employment of the required skills, the quality of most contract works are determined by the outputs of these unskilled individuals.

There is severe shortage of manpower both in terms of quality and quantity thereby hampering the project. There is presently an overall shortage of more than 50% of the required number of staff, while most of the available staffs have limited work experience in their fields of expertise. Hence, in the absence of adequate staff both in number and experience, the Corporation in most cases have to engage Engineers and Architects who have limited exposure and experience in the design and supervision of housing construction activities amongst others.

In general collusion and high bid prices offered by the contractors are becoming an increasing concern for the procuring agencies which leads to unnecessary loss of financial resources. The other prevalent practice is the fronting case involving subletting of work to lower Class contractors or award of work through Labor Contracts. Such practices have direct impact on the quality of the work since the works executed under such an arrangement are often carried out by contractors or individuals without the credibility of their competence being established besides working under reduced profit margins for the execution of the work. The lack of official identity and accountability of these contractors and individuals also pose increased monitoring problems among the procuring agencies.

OBJECTIVES

This study looks at the present situation of the mass housing project for the low income groups undertaken by the NHDC, their management system, identify constraints and provide recommendations. Specifically, the study has been carried out to achieve the following.

1. To assess the current performance of the mass housing for the lower income group carried out by the National Housing Development Corporation, in terms of the construction schedule and the cost.

2. To study the existing construction management system and identify constraints to the management of the housing construction projects.

3. To determine the causes of the problems and then find solutions

4. To formulate proposals to improve NHDC's ability and organization to effectively construct affordable houses meeting the needs of its target group.

Scope

This study focus on the construction management of mass housing projects for low income group in Bhutan, undertaken by the National Housing Development Corporation, and includes the housing projects at Changjiji, Thimphu, seven districts and two sub districts

LITERATURE REVIEW

Construction Project Management

1. Introduction

A construction project is an endeavor that is undertaken to produce the results that are expected from the requesting party. A project consists of three components: scope, budget and schedule. Scope refers to the work to be accomplished, budget to the cost in terms of money or labor work hours and schedule the logical sequencing and timing of the work to be performed (Oberlender, 2000)

All projects go through a typical life cycle curve, as shown in figure 3. The project starts with a conceptual phase, and then passes through a definition phase into the execution phase. Finally the work tapers off into a turnover phase (Ritz, 1994)

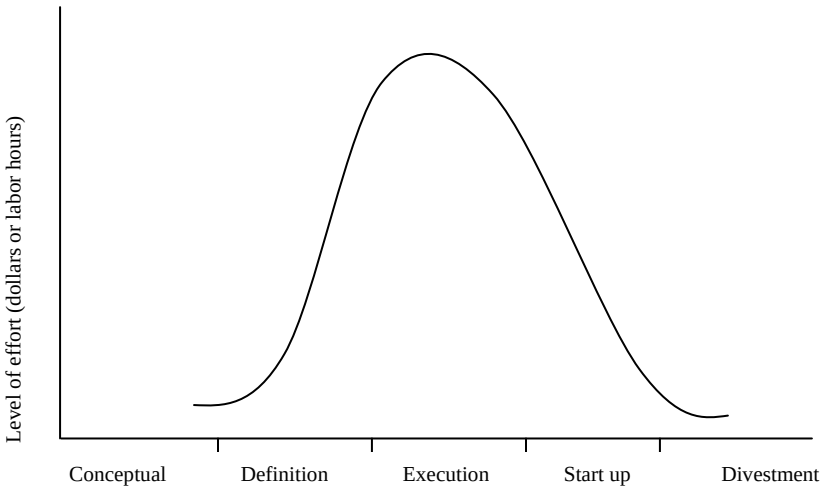


Figure 3 Project life cycle curve

Source: Ritz (1994)

The life cycle curve gains most of its vertical growth during the detailed design and procurement phases, and peaks during the construction phase. The major commitment of financial and human resources occurs during that part of the project. A project is in a continual state of change as it progresses from its start, as a need by the owner, through design development and finally construction (Oberlender, 2000). Figure 4 shows the various phases during the life of a project.

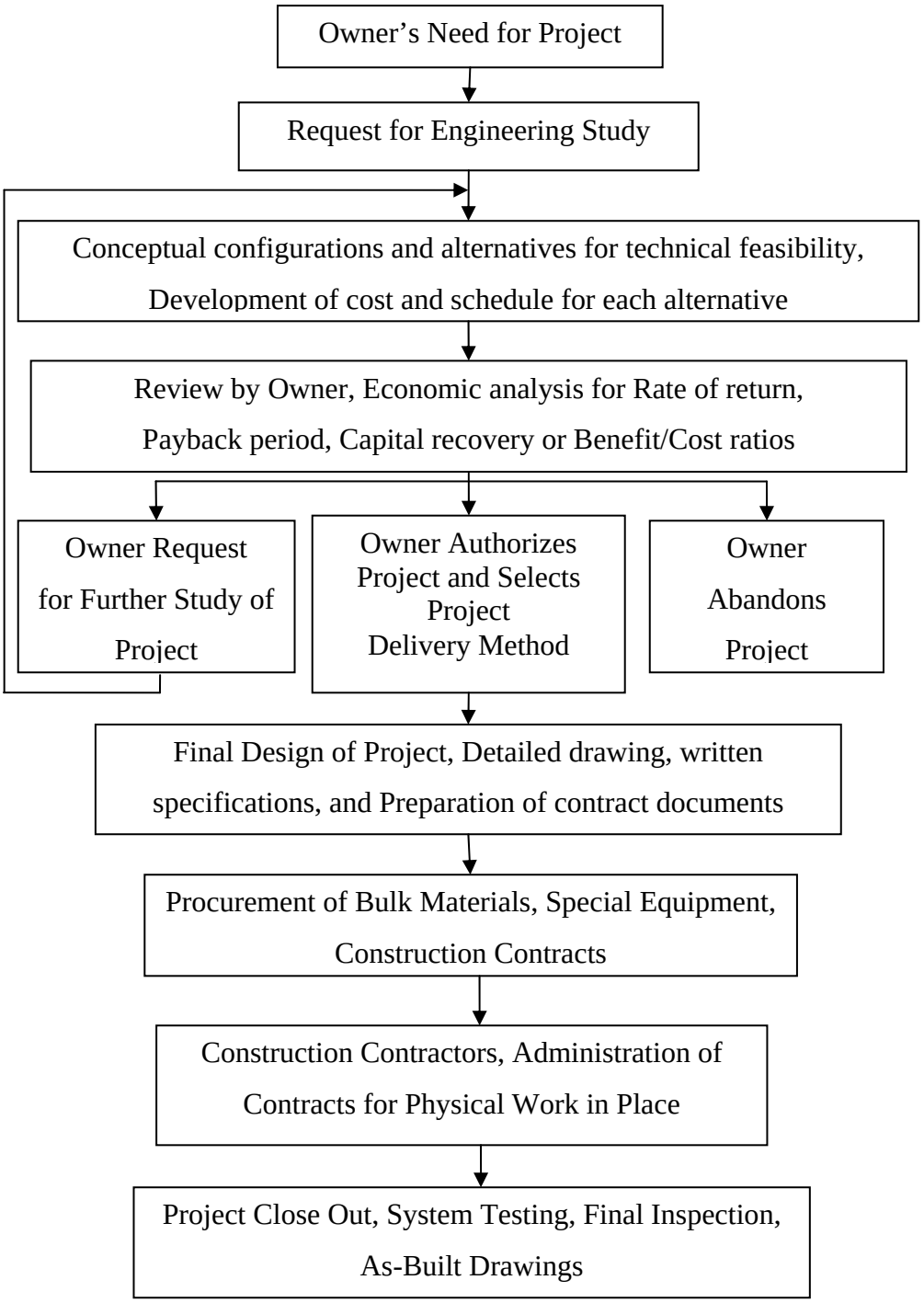


Figure 4 Phases of a project

Source: Oberlender (2000)

2. Project Management

Project management has evolved mainly because of the need to control costs and schedules. Projects have become more complex and demanding for the owners and participants. Hence the risks and potential for losses require better controls (Ahuja *et al*., 1994)

Project Management is the art and science of directing human and material resources to achieve stated objectives within the constraints of time, budget, and quality and to the satisfaction of everyone involved (Wildman, 1983). Alternatively it can also be defined as the a collection of tools and techniques (such as CPM and matrix organization) to direct the use of diverse resources towards the accomplishment of a unique, complex, one time task within time, cost and quality constraints. Each task requires a particular mix of these tools and techniques structured to fit the task environment and life cycle (from conception to completion) of the task (Atkinson, 1999).

The project management model is a three dimensional matrix as shown in figure 5. The functions, processes, and stages of a project management are dynamically linked, that is each simultaneously applied to the project (Ahuja *et al*., 1994).

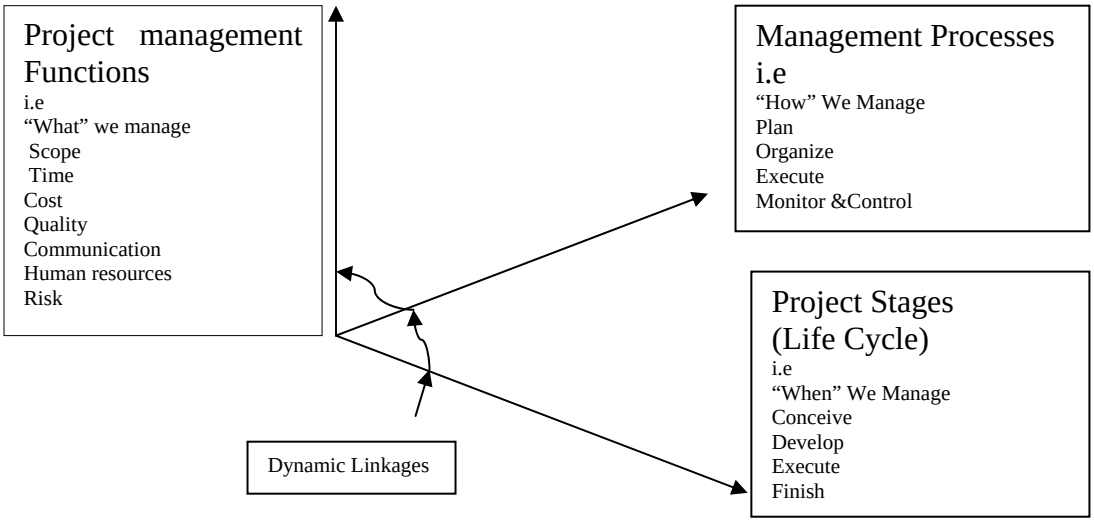


Figure 5 Project Management Model

Source: Ahuja *et al*. (1994).

Management theory identifies four essential management activities: scoping, planning, organizing and controlling that must be accomplished in any successful organization (Barrie and Paulson, 1992)

Scoping involves establishing realistic and specific objectives which establishes in advance the desired results. Objectives must be stated in definite and measurable terms which cover costs, schedules and quality or performance requirements. Full and unequivocal communication of project objective to project team members is essential for achievement of maximum performance.

Planning activities include programming, costing and scheduling. Planning for most projects will evolve from a high level plan in the early stages to a very detailed implementation plan during the performance phase. An integrated plan will involve a

work breakdown structure for estimating, scheduling, and costing direct and indirect work activities.

Organizing is the process used by managers to relate tasks to people, other firms, regulatory agencies and other interested groups in order to achieve an economical and timely performance. In developing an efficient organization, the manager must deal with the design of the structure, delegation of responsibilities, working relationships between individual and groups, and creation of a communication program designed to keep everybody fully informed.

Controlling requires an awareness of the current status of cost, schedule and quality performance compared to project goals. Control can be achieved through frequent personal inspection of the operation. The purpose of project control is to determine and predict deviations in the project so that corrective actions can be taken.

The various processes of project management are given in Figure 6 (Badiru and Pulat, 1995). It starts with the problem definition and ends with project termination. The problem definition stage is where the proposed project is identified, defined and justified. The project could be construction of an entirely new structure, implementation of new processes, or improving the existing facilities.

The process follows mission statement, planning, organizing, resource allocation, scheduling, tracking, reporting, controlling and finally termination. Scheduling is considered as the main focus in project management. The resources are allocated in such a manner that the overall project objectives are achieved within the specified time. If the project is not completed within the scheduled time, it experiences delay and most of the times cost overruns. Hence, proper tracking, controlling and reporting measure has to be formulated for successful implementation of a project.

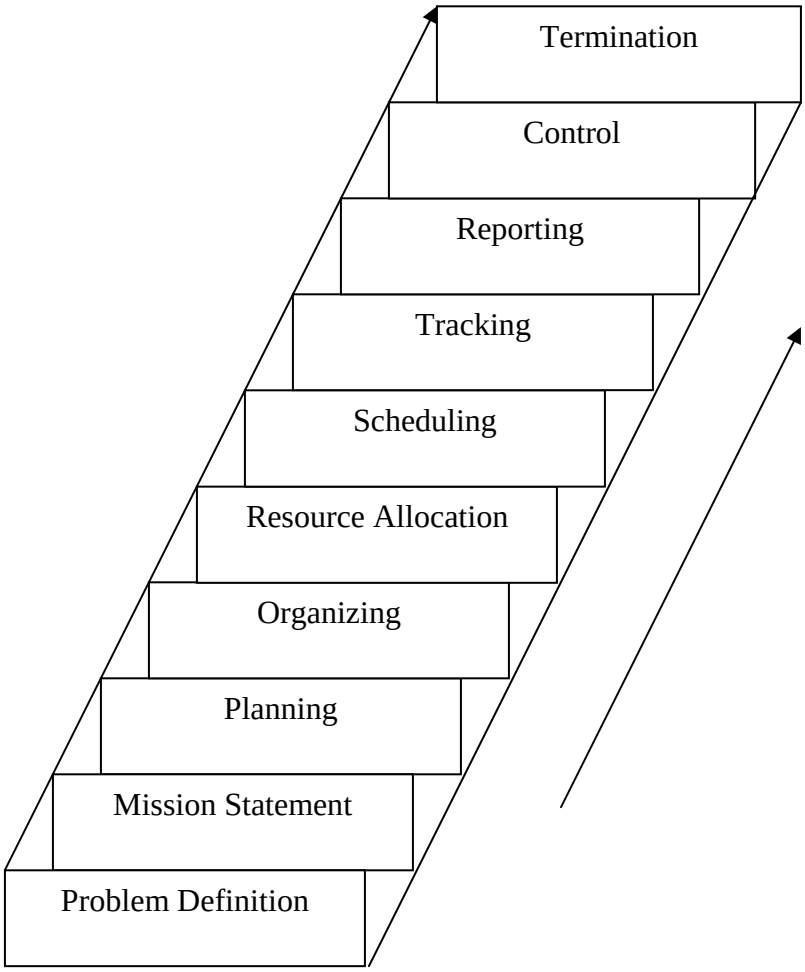


Figure 6 Project Management Steps

Source: Badiru and Pulat (1995)

2.1 Project Organization

A project organizational structure can be classified into three types: the functional organization structure, projectized organization structure and the matrix organization structure.

2.1.1 Functional Organization Structure

The functional approaches have been traditionally used in the construction industry. It involves the coordination of repeated work of similar nature by the same people. The strengths of these approaches will include high stability, high professional standards, incorporation of latest technology and an excellent corporate memory. Weakness can include low adaptability, minimum appreciation of overall project objectives, overly rigid operating rules, resistance to change and difficulty in developing well rounded project managers. Figure 7 shows a functional organization structure.

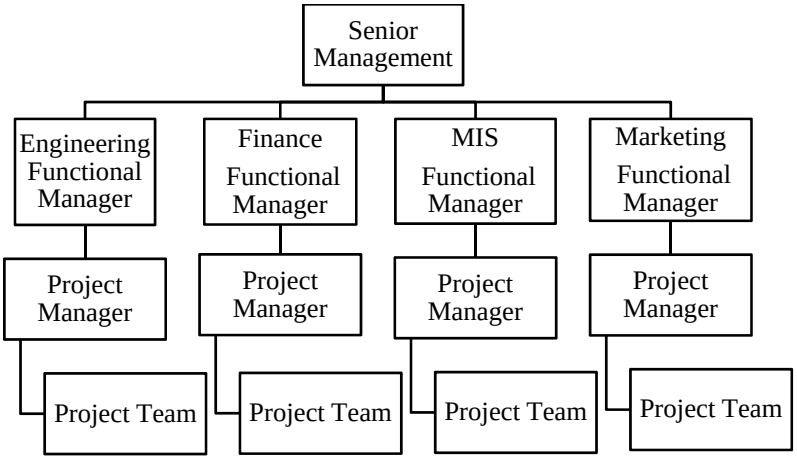


Figure 7 Functional Organization

2.1.2 Projectized Organizational Structure

The projectized organization structure also called the Task Force is defined as a team comprised of representatives from two or more functional departments reporting to a project manager and dedicated 100% for that particular project effort. The strength of the task force includes high adaptability and high understanding of the overall task and can foster an excellent team spirit if given the proper leadership. It features close

personal relationships and can be responsive to new ideas and methods. The weakness of the projectized organization features poor stability. Everyone may not have a corporate home for long term career development and for continuity of employment between assignment periods. Figure 8 shows a projectized organization structure.

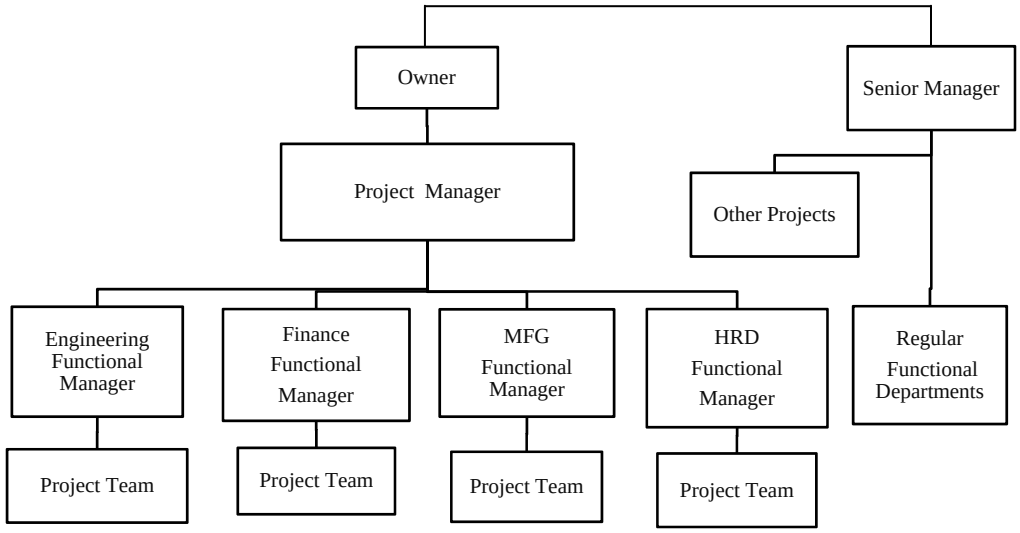


Figure 8 Projectized Organizations

2.1.3 Matrix Organization Structure

The matrix organizational form is something of a cross between a task force and a functional organization and represents an attempt to preserve strong points of each. It is a team of individuals from two or more functional departments reporting to a project manager, doing project oriented work for a product being driven horizontally across the organization, but dedicated less than 100% on any one project. Disadvantages include difficulties in precisely defining accountability to both functional and project managers. The matrix organization is appropriate when both project accountability and functional expertise are required. Figure 9 illustrates the matrix organization.

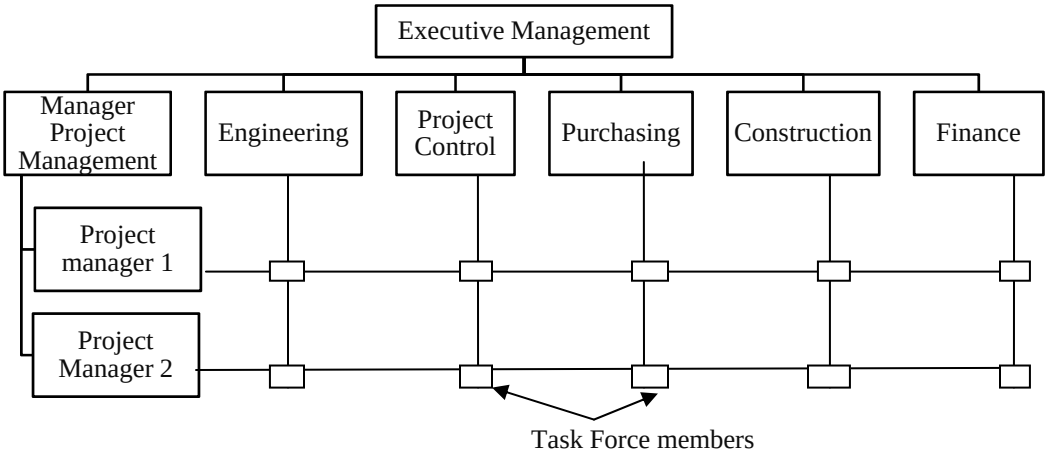


Figure 9 Matrix Organization

Source: Ahuja *et al* (1994)

2.2 Construction Contracts

There are many different types of construction contracts, distinguished primarily by the method of determining the final contract price (Fisk, 6th edition). The type of contract chosen may depend on several factors, including the identity and relationship if any of the owner and contractor, the completeness of the design, the type of work being done, and the need or desire for competitive pricing.

2.2.1 Fixed Price Contract

Lump sum contracts: It is the type of contract in which the contractor agrees to do specified construction for a fixed price set forth in the contract. The only changes allowed are for extras or change orders.

Unit Price Contracts: It is the type in which price for each unit of work constructed is agreed upon before the start of work. It is used for those works where it is difficult to calculate quantities in advance.

Fixed Price-Incentive Contracts: It is a fixed price contract that provides for adjusting profit and establishing a final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost.

2.2.2 Cost Reimbursable Contracts

Cost plus contracts are those in which the contractor is paid its actual cost of construction plus a specified markup to cover overhead and profit. The several variations that are commonly used are:

Cost plus percentage of cost: In this type of contract, the contractor is paid its actual cost plus a specified percentage of those cost for overhead.

Cost plus fixed fee: In this type, the contractor is paid the actual cost plus a fixed fee that is set in advance.

Cost plus incentive fee: In this type, the contract specifies time and quality criteria. If the contractor meets those criteria, they are paid the actual cost plus a set fee. If the work is completed earlier, the contractor is paid additional fee based on the scale set forth in the contract.

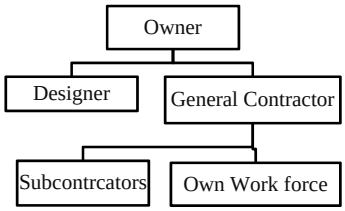
2.2.3 Guaranteed Maximum Price Contracts

The owner and the contractor agree that the project will not cost the owner more than a set price, the guaranteed maximum. The contactor is paid on a cost plus fixed fee or percentage of cost basis, but in no event more than the set maximum price.

2.3 Contractual Relationship

The various types of contractual relationship are as follows:

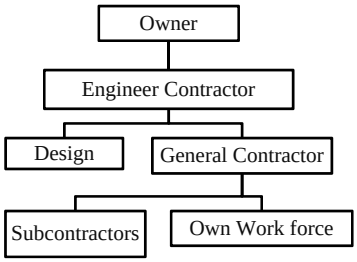
Traditional



- Separate Designer
- Single general contractor
- Numerous Subcontractors
- Fixed Price, unit price, guaranteed maximum, or cost plus a fixed fee construction contracts
- Negotiated professional fee for design services

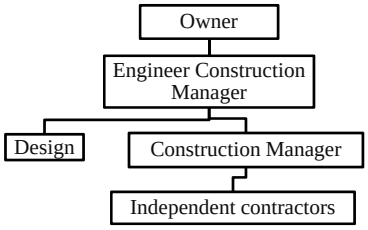
Turnkey

Design-Build



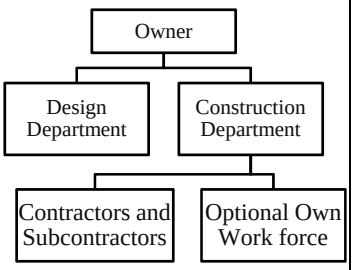
- Single firm responsible for both design and construction
- Specialty sub contractors
- Fixed price, guaranteed maximum, or cost plus a fee design construction contract.

Design Manager



- Single firm responsible for both design and construction
- Fixed price or negotiated individual construction contracts or sub contracts
- Fixed price, guaranteed maximum, or cost plus a fee design construction contract.

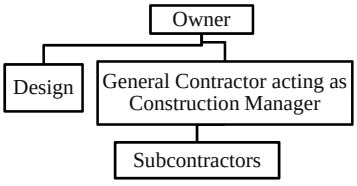
Owner-Builder



- Owner responsible for design and construction.
- Optional own forces work as contractors and sub contractors
- Fixed price, unit price, or negotiated construction contracts.

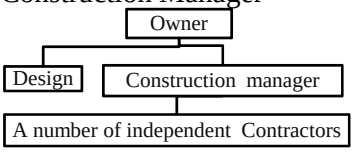
Professional Construction Manager

General Contractor



- Three party team of owner, separate designer, and general contractor acting as construction manager.
- Fixed price or negotiated independent subcontractors.
- Construction manager acting as agent for owner
- Negotiated professional fee for construction manager and design services.

Construction Manager



- Three party team of owner, designer, and construction manager.
- Fixed price or negotiated individual construction contracts directly with owner.
- Construction manager may act as owner's agent.
- Negotiated professional fee for construction manager and design services.

Figure 10 Alternate Contractual Approaches

Source: Barrie and Paulson (1992)

2.4 Project Planning and Scheduling

Project planning is the heart of proper project management because it provides the central communication for the work of all parties. It also establishes the bench mark for the project control system to track the quality, cost and timing of the work required to successfully complete the project (Oberlender, 2000). Project planning is the process of identifying all the activities necessary to successfully complete the project

Scheduling is the process of determining the sequential order of the planned activities, assigning realistic durations to each activity, and determining start and finish dates for each activity (Oberlender 2000). Shtub et al describes scheduling as the corner stone of the planning and control system.

There must be an explicit plan to guide the entire project. The plan must include and link the three components of the project: scope, budget and schedule. To develop an integrated total project plan, the project must be broken down into well defined units of work that can be measured and managed, which starts with the work breakdown structure. Selection of the project team with expertise in their field of work is the next process.

The technique used for project scheduling will depend upon the project's size, complexity, duration, personnel and owner requirements. The two general methods that are commonly used are: Bar (Gantt) Chart and the Network Based methods which includes the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT). The bar chart is the graphical time scale of the schedule. It is easy to interpret, but difficult to update. CPM is an effective technique for overall project scheduling and detailed scheduling of construction. It provides interrelationship of activities and scheduling of costs and resources. Program Evaluation and Review Technique (PERT) is commonly used as a probabilistic approach to scheduling.

Activities that repeat from unit to unit create a very important need for a construction schedule that facilitates the uninterrupted flow of resources from one unit to the next, since it is often this requirement that establishes activity starting time and determines the overall project duration (Harris and Ioannou, 1998). Repetitive Scheduling Method (RSM) is the technique used for such type of projects.

2.5 Project Control

Project Control is the pivotal activity that ties all the project management techniques together. Ritz (1994) defines it as the work of constraining, coordination and regulating action in accordance with plans to meet specific objectives. The basic mechanism of control function is as shown in figure 11.

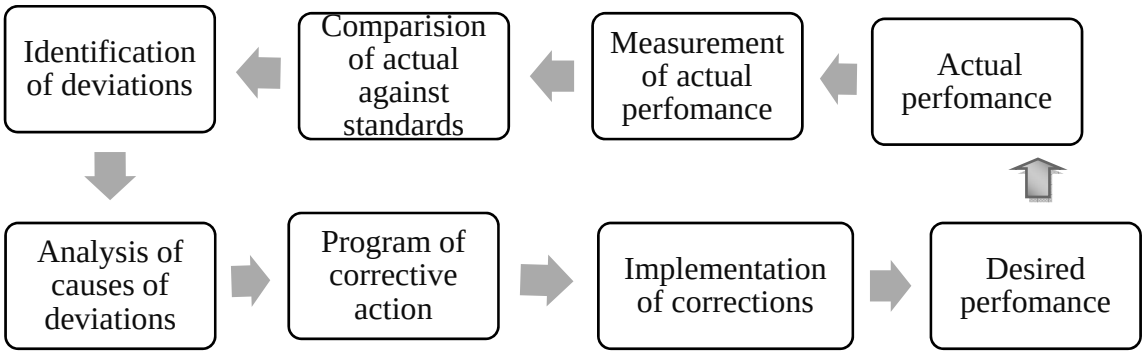


Figure 11 The control process

One of the most frequently prepared graphical displays used for project control is S- Curve, which is a plot of progress versus the time. Figure 12 shows the plot of the early, late, scheduled and the actual progress.

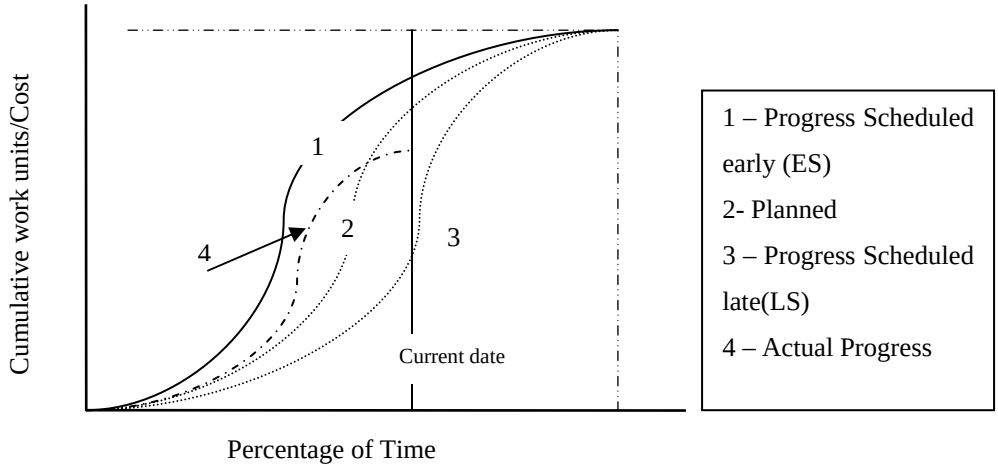


Figure 12 The Cumulative Progress S-Curve

The S-Curve is a graphical plot of some measure of the cumulative progress on the vertical axis against time on the horizontal axis. Progress can be measured in terms of money expended, man hours expended or the quantity surveys of work in place. Once the project is underway actual progress can be plotted and compared with that which was planned.

2.6 Project Performance

A successful project management requires planning with a commitment to complete the project, careful appointment of a skilled project manager, spending time to define the project adequately, correctly planning the activities in the project, ensuring correct and adequate information flows, changing activities to accommodate frequent changes on dynamic, accommodating employees' personal goals with performance and rewards, making a fresh start when mistakes in implementations have been identified (Munns and Bjeirmi, 1996)

The earned value system is used to measure the performance of a project. It incorporates scope and integrates with cost and schedule. The earned value analysis

combines the three elements of budget, schedule and scope by using cost as the common exchange medium (Cioffi, 2006). The BCWS (Budgeted cost of work scheduled) is the value of the work (based on the budget) that is supposed to have been performed as of today, BCWP (Budgeted cost of work performed) is the actual value of the work (based on the budget) that has been performed as of today and ACWP (Actual Cost of work performed) is the actual cost of the work that has been performed as of today. The variances thus worked out are as follows:

Cost Variance, CV = BCWP – ACWP

Schedule Variance, SV = BCWP – BCWS

Cost Performance Index, CPI = BCWP/ACWP

Schedule Performance Index, SPI = BCWP/BCWS

The value of cost performance index greater than 1 indicates that the cost of the actual work performed as of today is less than the budgeted cost, whereby the cost is under budget and is a good indication. The value of less than 1 indicates that there is cost overrun. Likewise the value of schedule performance index greater than 1 indicates that the work performed is ahead of schedule and less than 1 show that the project is behind the scheduled time.

Mass Housing

The term mass housing or mass house building projects (MHBP's) are defined as the design and construction of standardized house units usually in the same location and executed within the same project scheme (Ahadzie *et al*., 2007).

1. The mass housings are based on one or more standardized designs in the sense that the architectural designs of all phases should largely be same to ensure that the concept of repetition is met.

2. They involve the construction of domestic residences.

3. They should potentially be located in the same area and be a part of the same scheme and contract conditions.

The mass housing projects differ from the traditional projects and management of these projects is inherently more complex and difficult due to the reasons stated below:

1. These projects are based on standardized design; there is the need to identify the stages in production at which control is to be exerted and there is the need for production time between stages including delivery of house-units

2. Because of their unique nature, the setting up of the production system involves two associated problems; the minimizing of synchronizing loss and the maximizing of resource utilization.

3. Moreover, depending on the quantity of house-units involved, these projects are often relatively large-scale and can stretch over a considerable production area.

4. Numerous interrelated skills are involved.

Past Studies on Construction Project Performances and Management

Kuprenas and Madjidi (1999) carried out a study on the Implementation of Project Management in Public Engineering Organization at the Bureau of Engineering, City of Los Angeles. Although the quality of Bureau of Engineering's designs had been excellent, some programs had experienced significant delays and cost overruns in the design and construction of projects. Several groups had analyzed the Bureau of Engineering and consistent to all these reviews was the specific recommendations to move towards a strong project management style of project management style of project deliver and organization.

As a result the bureau mandated a dramatic shift to improve project delivery. They organized themselves into a program based matrix organization with a project manager being focus for project delivery with the project conception to conclusion responsibility. In addition to extensive training program, other two key elements were establishment of project management organization structure and defining the roles and responsibilities for the project delivery team members. Part of the shift towards a project management approach included shift towards four new processes which are lean thinking, formal performances agreements, defining methods to measure performances and establishing methods to report project performance results.

The implementation had produced some significant improvements in program delivery. Operating under new organizational structure with projects managed by new single-hat project managers, the bureau achieved 40% reduction in time from delivery in of the work order to award of construction contract in street program, a 50% improvement in annual capital program delivery in street program, 50% improvement in annual capital program delivery in storm water program.

Kinley *et al* (2007), in his study on the Project Performance of Bhutan Building construction, had found that the construction projects in Bhutan have been delayed beyond the scheduled completion time. The time performances of projects executed by the School Planning and Building Division (SPBD), National Housing Development Corporation (NHDC), and District Engineering Sectors (DES) of Thimphu, Paro and Haa from 1998 to 2006 are as presented in table no 3.

Table 3 Project delay situation in Bhutan

Item No.	Type of project	Projects executed (No.)	Projects Completed on time (No.)	Projects delayed (No.)	Projects delayed (%)
1	School buildings	24	11	13	54
2	Residential buildings	13	9	4	31
3	Office buildings	7	4	3	43
4	Overall	44	24	20	45

54%, 31% and 43% of the school, residential and office building construction projects respectively had been delayed beyond the scheduled date of completion. It was found out that labor factor category was considered to be the most significant for project delays. This implies that the Bhutanese construction industry is still labor intensive. The other top five significant factor categories include equipment, contractor, design, and material. The other significant observation was that contractor related factor category was considered to be only the third important whereas in the individual causes of delay the contractor related factors are considered to be the most critical for project delays. Hence, it could be said that labor plays a dominant role in Bhutan construction industry.

The cost performances are as presented in table no 4.

Table 4 Project cost overrun situation in Bhutan.

Item No.	Project Title	Projects executed (No.)	Projects with cost saving (No.)	Projects with cost overrun (No.)	Projects with cost overrun (%)
1	Construction of schools	24	7	17	71
2	Construction of residences	13	9	4	31
3	Construction of offices	7	3	4	57
4	Overall	44	19	25	57

71%, 31% and 57% of the school, residential, and office building construction projects respectively suffered cost overruns. The five major causes of cost overruns were additional works given during construction that were not foreseen during bid preparation, reasons that yield construction delays, increase in wages, increase in material prices and interference from top level management resulting in substantial changes to the original scope of the work.

Chen and Partington, 2006 and Chen, Partington and Wang, 2007, identified three different concepts of project management in the UK and China: project management as planning and controlling, project management as coordinating relationship and project management as developing relationships.

Project Management as planning and control includes the ability to plan, knowledge of construction work, knowledge of commercial management, ability to communicate, and ability to manage team. Project Management as coordinating relationship includes one additional attribute: ability to coordinate and project management as developing relationship includes another new attribute which is ability to build new relationship.

Many researchers have conducted surveys to identify the causes of delay in the construction industry in various countries. Ogunlana *et al*. (1996) studied the delays in building projects in Thailand, as an example of developing economies. They concluded that the problems in the construction industry in developing economies could be nested in three layers: 1) problem of shortages or inadequacies in industry infrastructure, mainly supply of resources; 2) problems caused by clients and consultants; and 3) problems caused by incompetence of contractors. The project suffered delays mainly because materials, mainly cement was in short supply, technical personnel were over stretched, having to do so much so soon in their careers. However, as the study was carried out during the boom years the situation may not be the same at present.

Chan and Kumaraswamy (1997) conducted a survey to evaluate the relative importance of 83 potential delay factors in Hong Kong construction industry and found five principal factors: poor risk management and supervision, unforeseen site conditions, slow decision making, client-initiated variations, and work variations. Lo *et al*. (2006) carried out a similar study in Hong Kong construction industry and found that inclement weather, unforeseen ground conditions, inaccurate bills of quantities, and delays in providing design information are the major factors causing delays in construction projects.

Alwi and Hampson (2003) conducted a survey to determine the most important causes of delays within building projects in Indonesia. The study identified that the design changes, lack of trades' skill, and slow decision making are the major causes of delays. Similar study to identify the causes of delay was carried out by Abdul-Rahman *et al*. (2006) in the construction industry in Malaysia and found that shortage of manpower, poor site management, and client influence were the major factors.

The result of the above surveys in Thailand, Hong Kong, Indonesia, and Malaysia are summarized in Table 5.

Table 5 Major Causes of delay in Thailand, Hong Kong, Indonesia, and Malaysia.

Sl. No.	Major causes of delay	Country	Researchers
1	Shortages of materials	Thailand	Ogunlana *et al*. (1996)
2	Changes of design		
3	Liaison problems among the contracting parties		
1	Unforeseen ground conditions	Hong Kong	Chan and Kumaraswamy (1997)
2	Poor site management and supervision		
3	Slow decision making by project teams		
4	Client-initiated variations		
1	Design change	Indonesia	Alwi and Hampson (2003)
2	Lack of trades' skill		
3	Slow in making decisions		
1	Shortage of manpower	Malaysia	Abdul-Rahman *et al*. (2006)
2	Poor site management		
3	Client influence		
1	Inclement weather	Hong Kong	Lo *et al*. (2006)
2	Unforeseen ground conditions		
3	Inaccurate bills of quantities		
4	Delays in providing design information		

Odeh and Battaineh (2002) have done research on the delay in construction industry by considering different aspects of delays. Firstly, they considered the cause of delays which are limited to those for which contractors are entitled for time extension. This analysis did not cover the causes of delays that contractors are responsible for, such as labor and equipment, planning and site management, construction methods, adequacy and capability of contractors etc.

Secondly, their study is based on the reported number of time extensions and not the extent of delay attributed to the different causes of delay. By carrying out that research they came across that most of delays in Jordan construction industry occurred due to owner's interference, inadequate contract experience, financial problems, improper planning, labor productivity, slow decision-making, etc. The findings of delays in Jordan and Turkey construction industry are summarized in Table 6.

Table 6 Reasons of delay in Jordan and Turkey

Sl. No.	Reasons of delay	Country	Researcher
1	Unforeseen site condition	Jordan	Al-Momani (2000)
2	Bad weather condition		
3	Economic condition		
4	Late delivery of material		
5	Increase work quantity		
1	Shortage of resources	Turkey	Arditi *et al*. (1985)
2	Financial difficulties faced by		
3	public agencies and contractors		
4	Delays in design work		
5	Frequent change order / design		
6	Deficiencies in organization		
1	Owner Interference	Jordan	Odeh and Battaineh
2	Inadequate contractor experience		(2002)
3	Financial problems		
4	Improper planning		
5	Labor productivity		
6	Slow decision-making		

Causes of delays and cost overrun in Nigerian construction projects were identified by Dlakwa and Culpin (1990), Elinwa and Buba (1993) and Mansfield *et al*., (1994). According to them, human resources and management were the main problems in Nigerian construction industry. Taking remedial measures in advance would minimize the delays and cost overrun. External factors can be identified as usually being

responsible for project delays and increase of cost due to excessive bureaucratic checking and approval of procedures, unclear project definition and insufficient geological investigation at feasibility stage of the project. Reasons of delays in Nigerian construction industry are as summarized in Table 7.

Table 7 Reasons of delays in Nigerian construction industry.

Sl. No.	Reasons of delay	Researcher
1	Financial problems of the owner	Dlakwa and Culpin (1990)
2	Cash flow problems of the contractor	
3	Fluctuation of cost of materials	
4	Fluctuation of cost of labor	
5	Fluctuation of cost of plant	
1	Shortages of materials	Elinwa and Buba(1993)
2	Improper planning	
3	Poor contract management	
1	Lack of human resources	Mansfield *et al*.
2	Unclear project definition	(1994)
3	Insufficient geological investigations	

Mansfield *et al.,* (1994) proposed that the reduction of poor contract management skills can be done by providing sufficient training facilities from senior and middle management levels. The local contractor's technical knowledge can be improved by giving more opportunities to the local's to work with international contractors. Lack of availability of materials can be avoided by giving higher priority to improve local material stocks and supply.

Scott *et al*., (1993) mentioned some common remedies for delays, as summarized in Table 8

Table 8 Common remedies for delays

Sl. No	Responsible party	Example	Remedy
1	Employer's responsibility	Variations, failure to provide site / information	Extension of time with recovery of overhead costs
2	Contractor's responsibility	Insufficient labour/plant remedial work	No compensation either time or cost
3	Neither party responsible	Strikes, riot, exceptional adverse weather, force majeure	Extension of time to defray deduction of liquidated damages but no cost

To prevent delays in construction phase, change orders require rapid approval. (Ehrenreich–Hansen 1994). Construction projects are bound to encounter change orders. If this is identified by the owner and contractor alike, necessary planning is required at the inception of the project, and unproductive time and effort can be prevented.

MATERIALS AND METHODS

1. Literature Review

Books and articles on the construction project management were studied, in order to acquaint with the available body of knowledge in the construction management field and to provide a theoretical background. The review of the past studies also provided some ideas about the management concepts used for various construction works in countries around the world, which have been used as a basis for determination of the solutions for meeting the targeted completion date and estimated cost while providing housing for the low income groups in Bhutan.

The project management system of the National Housing Development Corporation was studied, whose mandate is to promote housing development in the country.

2. Data Collection

Questionnaire survey was used to gather information on the current construction management system practiced. The data was collected through distribution of questionnaires to key personals from NHDC, the owner organization involved in the mass housing project, which included the general manager, project managers, project engineers and the site engineers. One to one discussion/interaction was also carried out with some of the staffs involved to understand the general practices being followed, problems faced and required improvements. Documents related to the projects were studied to gather the information on the project cost, time, contracting strategy, project control system, etc. Eleven questionnaires were distributed to the above mentioned staff of which only eight were returned (73%)

The questionnaires were framed with help from the literatures of construction management, and the researcher's experience in Bhutan construction industry. They consisted of all those aspects of management which included the project organization, construction contracts, project delivery system, project planning, scheduling, project control and the performance.

3. Data analysis

The data collected from NHDC has been used to study the existing construction management system used, the cost, quality and schedule performances of the mass housing project, where from the problems in the management system was identified. The reasons for the problems encountered as stated in the statement of problems, were then worked out. Table 9 shows the data analysis methodology.

Table 9 Data analysis methodology

Input	Process	Output
1. Collected data from NHDC	Study the prevailing system of construction management for the low income group mass housing.	NHDC's problems.
2. NHDC's problems	Comparative analysis with the standard construction management practices.	NHDC's required improvement, in the field of housing provision for the low income group was worked out
3. NHDC's required Improvement	Construction Management tools and techniques	Improvement of the NHDC's Construction Management system in provision of the housing for the low income group.

RESULTS AND DISCUSSIONS

1. Organization

The National Housing Development Corporation (NHDC) was formally established in 2003 to help the people to realize the dream of having a shelter. It is a government undertaking corporation under the Ministry of Works and Human Settlement. After its establishment, it has assumed the responsibility for the construction of low income housing, management/maintenance of the existing Government housing from the Department of Urban Development and Housing and the Department of National Properties and many more (www.nhdc.gov.bt).

The NHDC's organization is a functional organizational structure as shown in figure 13. The four divisions are grouped as per their functions and are headed by the general manger. The Design and Planning Division is responsible for carrying out the feasibility survey, architectural, structural, plumbing and electrical design, estimation, tendering formalities, research on housing technologies, landscaping and consultancy services. The Construction Management Division looks after the day to day activities at the construction site and is responsible for the quality, cost and schedule control of the project. The real estate division is responsible for the house allotments, operation and maintenance of the real property, housing market analysis, data management and land acquisition. The Administrative and Finance Division's responsibilities include day to day administrative works, budget management, financial management and manpower training and recruitment.

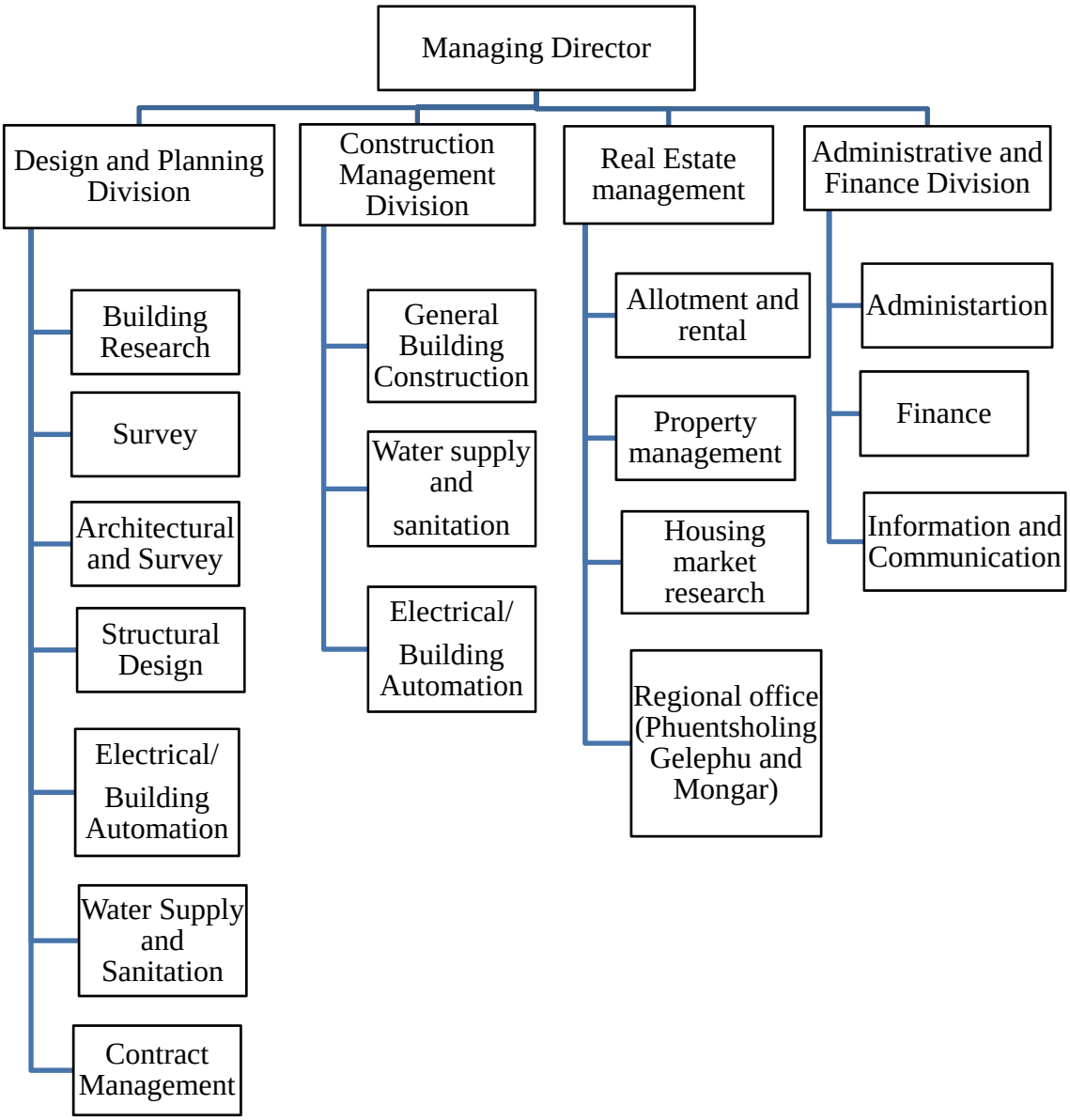


Figure 13 Organogram of the NHDC

A housing project involves surveyors, soil investigators, and architectural, civil, structural, mechanical, and electrical works, beginning with survey and site investigation, followed by architectural design and the various other engineering designs. As the work moves from discipline to discipline, immense time is spent and it becomes difficult to know where the project is or what its status is. A channel of communication is required

between the various divisions, which otherwise can cause misinterpretation of information and delay in obtaining answers.

To increase the emphasis on project cost, schedule and general coordination, a matrix organization is proposed for the NHDC as depicted in the figure 14.

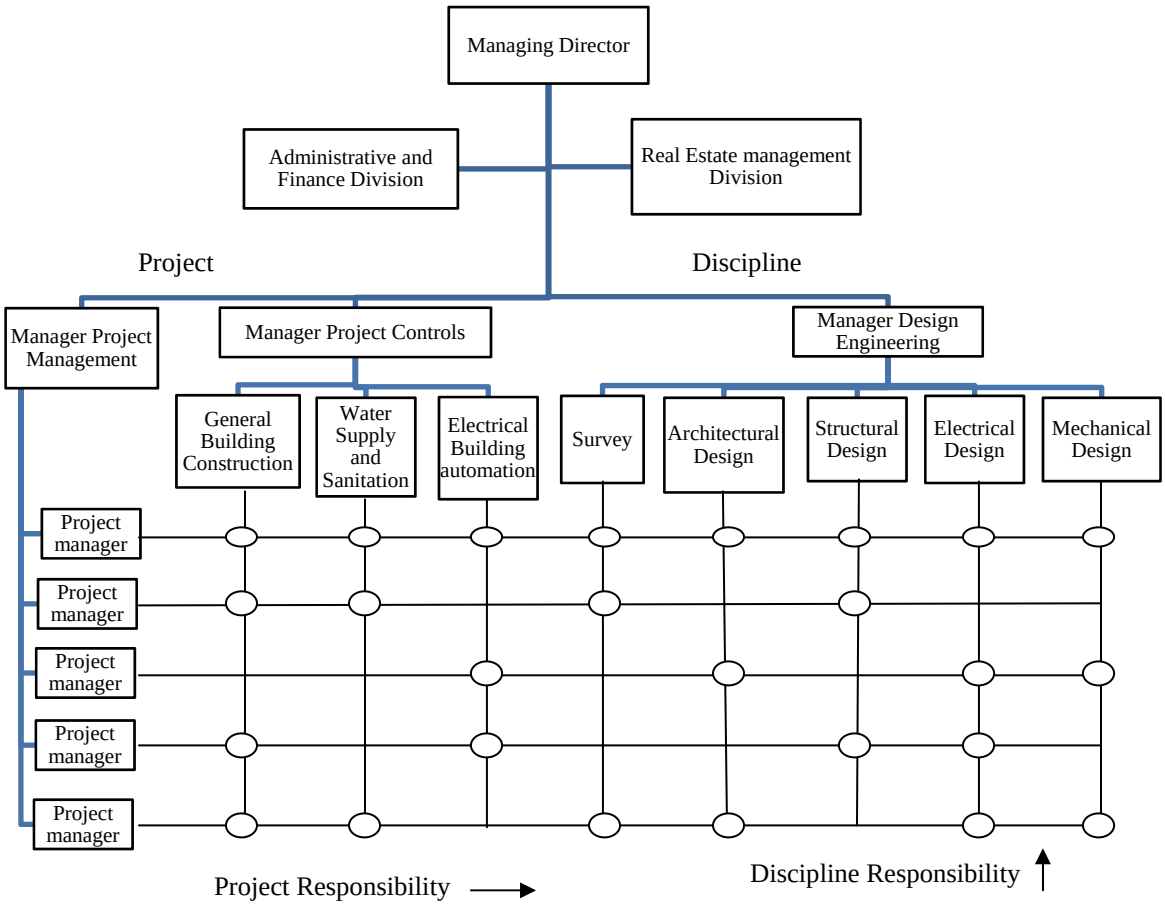


Figure 14 The recommended organizational structure

The matrix organization provides a work environment with emphasis on the project. Each project is defined by the horizontal line on the matrix. The project manager is responsible for overall project coordination, interfacing of the disciplines, and monitoring of the overall project cost and schedules. The various design disciplines are

responsible for providing technical expertise, quality performance, and cost and schedule for their particular part of the project. No one person works for the other on the project team, instead everybody works for the project (Oberlender 2000). However evaluation on the benefit on the construction performance, on change over to the matrix organizational structure needs to be carried out after its implementation for some years.

2. Project Planning and Scheduling

From the observations of the documents and discussions with the staff involved with the mass housing for the low income group, it was found that they used only bar charts for general planning and scheduling, though in the questionnaires some had mentioned about the use of CPM, PERT, Bar Charts and also the repetitive scheduling method. Detail planning and scheduling of the work packages were not carried out. The project progress was reported in the form of bar charts. There was no system of use of milestone, and therefore no basis for checking on the project progress, both in respect of cost and schedule. Milestone dates during different construction periods should be incorporated so as to act as a checking point for the project progress, thereby reducing the project delay risk by dividing into many check points, during the life of the project.

Some of the respondents have mentioned that they were not given enough time for proper planning leading to many problems later on resulting from poor and rushed planning. Without proper planning and scheduling of the works, many works carried out within the mass housing project were delayed as shown in table 9. The buildings in Phase I and II were delayed mainly because of the delay in handing over of the site to the contactors due to the incompletion of the site clearing and the cutting works, and delay in the supply of the prefabricated door and window components, which could be attributed to poor planning. Some of the delays in the construction of the infrastructure works were also due to poor planning, as one contractor was in the way of another thereby hampering the smooth flow of work.

Project planning and scheduling can serve as an effective means of preventing problems. It can prevent delays in work, a major cause of late project completion and cost overruns. It can also prevent low worker morale and decline in productivity that is caused by lack of direction (Oberlender, 2000). It is therefore recommended that planning should begin before starting of the work and adequate time should be given for planning. All aspects of the project i.e scope, budget, schedule and quality should be included. All the people who actually do the work should be included in the planning and scheduling process, and flexibility should be built into the plan keeping allowance for changes and time for reviews and approvals.

The thoroughness and completeness of the scope of the project has a significant impact on the total project cost. An inadequately defined project scope leads to changes during design and/or construction, costly change orders, and claims and disputes which lead to major cost overruns and delays (Oberlender, 2000). Figure no 15 illustrates that the time to achieve savings and reduce changes is in the early life of the project and not at the start of the construction. Therefore it is of upmost importance to see to that proper planning is carried out before the start of the construction.

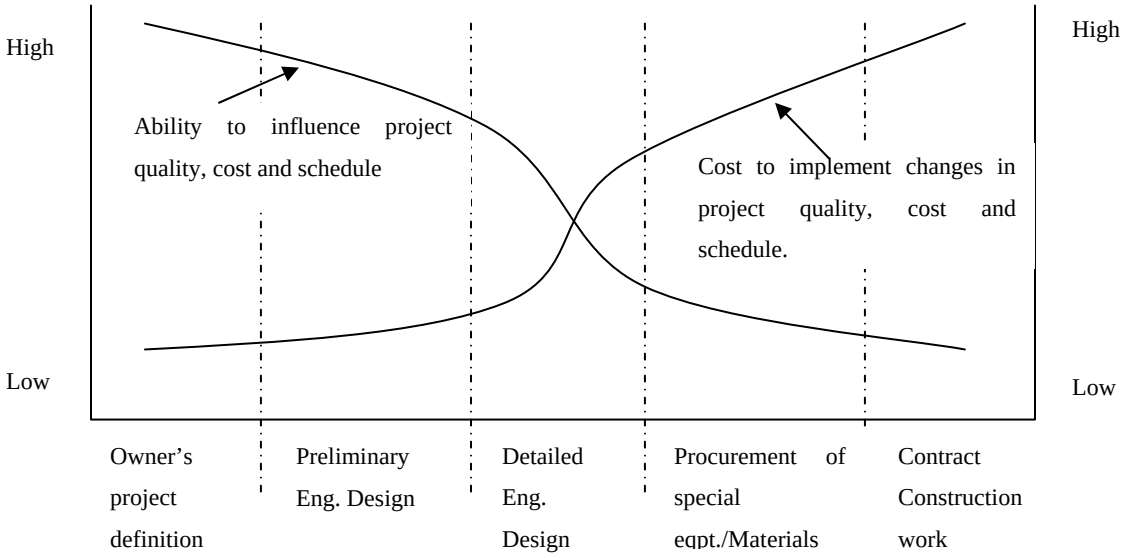


Figure 15 Importance of Clear Project Definition during the early phases of a project

Source: Oberlender (2000).

To provide a systematic way to plan and control works, it is necessary to develop a preliminary work breakdown structures (WBS) that identifies the major tasks that must be performed. A detailed list of tasks should be prepared and grouped into phases, which gives detail on the estimated work quantity and interdependencies of the work. A time schedule should be attached to each task

As for the scheduling technique, it is strongly recommended to start with the use of the Network Analysis System, which can be classified into two methods; CPM and PERT. CPM is deterministic way while PERT concerns probability. Both of them are a graphical display of the work activities and shows the interdependencies of activities, and provide a complete method for project planning, scheduling and controlling. The human capabilities and abilities needs also to be developed through provision of training in the use of software of the above two methods.

The Repetitive Scheduling Method (RSM) can be most effectively used for the mass housing projects as they have repetitive activities from one unit to another. By using of the RSM, it is assured that there is uninterrupted flow of resources from one unit to another, as it is often the requirement that determines the project duration (Harris and Ioannou. 1998).

3. Project Delivery System

The traditional system or the design/bid/build system of project delivery system is still in use like in all other construction projects in Bhutan as illustrated in figure no 16

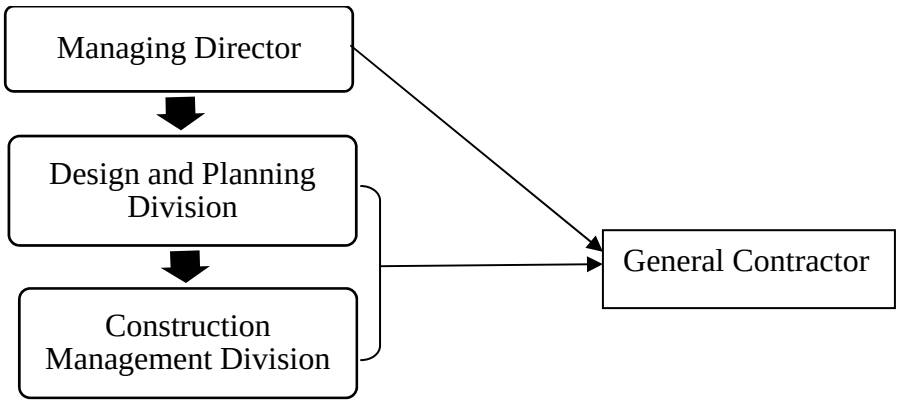


Figure 16 Project Delivery System

The Design and Planning Division of the Corporation is responsible for all the design, estimation and preparation of the contract documents. The design part starts with the survey of the proposed construction site after which the architectural design is carried out. After its completion, structural, electrical, and plumbing designs are done. Call for tenders are floated in the local news papers and the radio after the completion of the estimation and the preparation of the tender documents. Prequalification of the contractors were not carried out for the housing projects. The time period required for all above processes are shown in Figure 17.

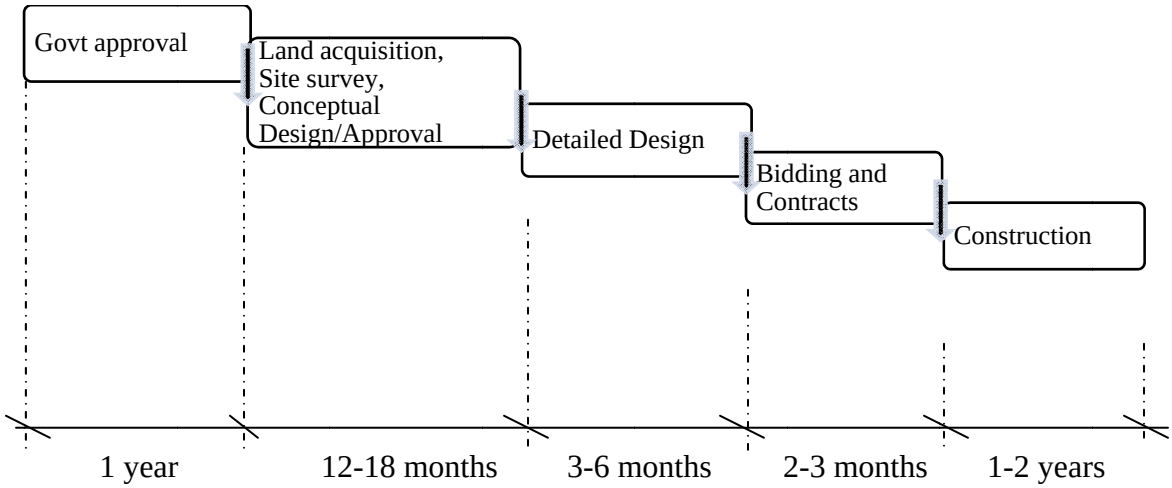


Figure 17 The life cycle of the NHDC mass housing projects

The Construction Management Division then takes over after the contractor has been awarded the works. The division is headed by a general manager. The project managers, one each for the Changjiji housing, and District housing are then responsible for monitoring of the construction work quality, cost, schedule, and directing as effective leaders.

As can be seen from figure 17, a lot of time was spent in the project delivery process; more than two years excluding the Government approval time before the construction could actually be started. It is therefore proposed that for future projects the NHDC switch on to the turn key project delivery system whereby the total time required to complete the project is shortened and also there will be flexibility to make changes in the project during construction. A turnkey delivery system is a two party arrangement between the owner and the design/build firm, who will carry out both the design and construction. There is no requirement for the design to be complete before starting the construction. This contractual arrangement however requires extensive involvement of the owner for decisions that are made during the selection of design alternatives and the

monitoring of the costs and schedules during construction. Figure 18 shows the proposed contracting arrangement.

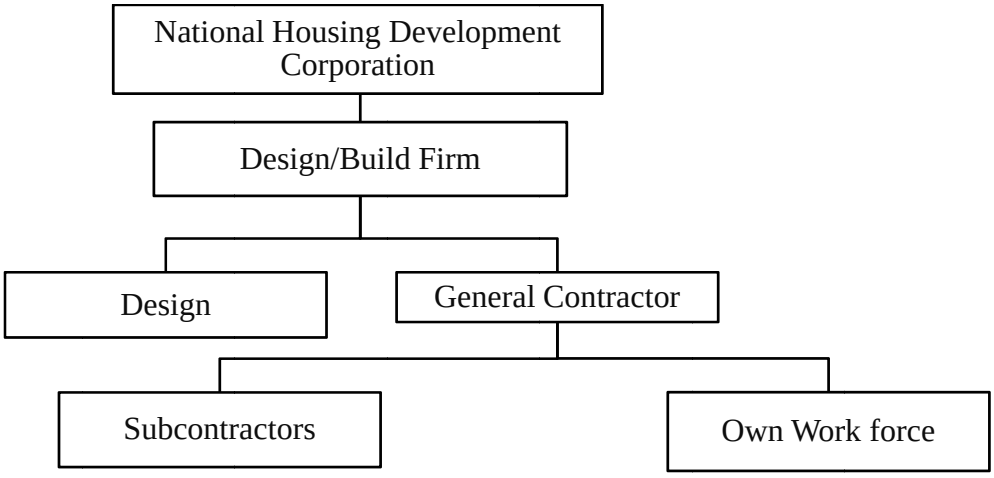


Figure 18 Proposed project delivery system

With the use of Design/Build project delivery system, the construction can be started before the design is complete and therefore the project delivery time will be reduced as depicted in figure 19.

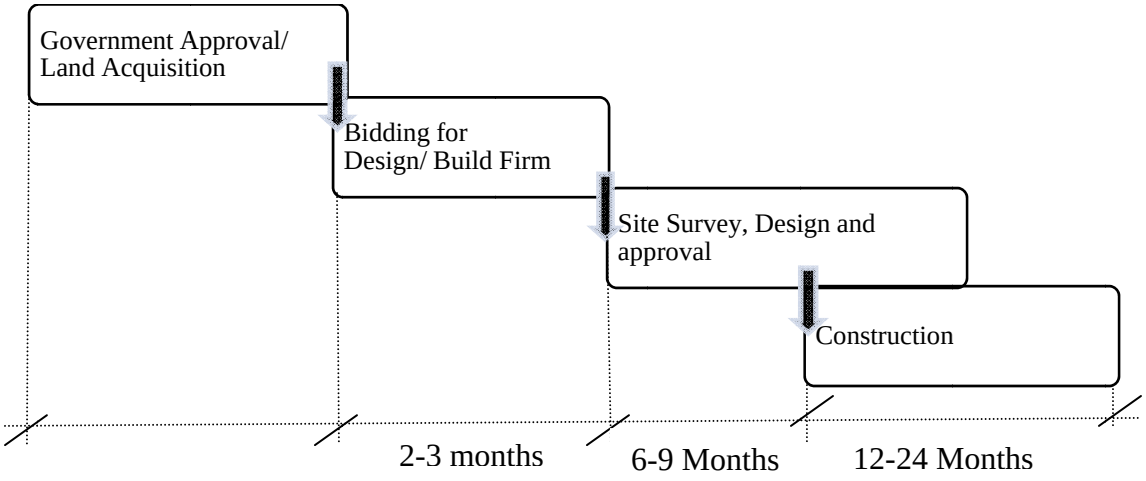


Figure 19 New project life cycle

From the figure 19 we can see that the construction can be started within 8-12 months of the government approval and land acquisition. There will be deduction in the project delivery time in the preconstruction phase for about a year. However the actual impact on the construction performance needs to be evaluated after the implementation of the turn key project.

In absence of qualified personnel and lack of time, sub-soil investigations were not carried out before the design of the buildings. Also as mentioned earlier, prequalification of the bidders was not carried out. The successful execution of contracts for large buildings, civil engineering, supply and installation projects requires that contracts are awarded only to firms, or combinations of firms, that are suitably experienced in the type of work and construction technology involved, that are financially and managerially sound, and that can provide all the equipment required in a timely manner. The assessment by an implementing agency of the suitability of firms to carry out a particular contract prior to being invited to submit a bid is a process called prequalification (Prequalification of Bidders User's Guide, Asian Development Bank, 2006) Prequalification is followed by a closed competitive bidding procedure in which only those firms meeting specified prequalification criteria are invited to submit a bid. An applicant's capabilities to perform the contracts satisfactorily are established in respect of;

1. Eligibility
    a. Nationality
    b. Not having been blacklisted
    c. No conflict of interest
2. Financial Situation
    a. Historical Financial Performances
    b. Average annual construction turnover
3. Experiences

a. General Construction experience
b. Specific Construction Experience

4. Pending litigations
5. Present work load, available major resources i.e. personnel, equipments and machineries.
6. References from previous clients.

As of June 2008, there are 1938 contractors registered under the various categories, the list of which is depicted in Table appendix B2. It is recommended for the NHDC to prequalify the bidders on the basis of the qualification criteria stated above, so as to screen only the qualified and the best bidders for the construction works. In the open competitive bidding process which was followed for the mass housing projects all the contractors possessing a valid contract license were allowed to bid for the work, which normally does not guarantee that the best contractor would win the bid.

The evaluation of the bids after submission by the bidders is carried out as per the guidelines prepared by the Standard and Quality Control Authority, Ministry of Works and Human Settlement. The contractor's annual average income, bid capacity, credit worthiness, technical staff and equipment, years in the job, and work done are scored under the "technical bid" which has a 60 point weightage. The evaluation is done by evaluating committee consisting of engineers of the NHDC based on the information provided by the bidders. The balance 40 points are awarded to the quoted or "financial bid". The recommendations are then submitted to the tender committee for review and subsequent approval to award the work to the lowest evaluated bidder, who is the one with the highest score.

The winning bidder has to deposit 10 % of the contracted amount to the owner agency as the performance security deposit after it is issued with the letter of acceptance, which will be returned back after the completion and handing over of the work. On

payment of the final bill 10% of the amount is retained with the owner till the defect liability period.

4. Construction Contracts

The mode of payment used in the mass housing project for the works done is the unit price contract. The prices for each item of works are quoted during submission of the bids by the contractor. The unit for each item of works may be in running meters, cubic meters, square meters, kilogram, or numbers. In completion of the works the quantity of works carried out are measured and payment is done in the agreed upon rates per unit. So the rates are fixed at the start of the work. The total contract amount varies with the quantity of the work done, so extreme care is required in verification of the contractor's payment claim and the work quantity. The difference in the measured quantity of the work done has been a basis for many audit objections, though care is taken to measure accurately. The measurement is carried out jointly by the site engineers of the contractors and the National Housing Development Corporation.

The Bhutan Schedule of Rates (BSR) prepared by the Standard and Quality Control Authority, Ministry of Works and Human Settlement, gives the rates for all items of works included in any construction and is basically used as a basis for preparation of the estimates. It is also used by the contractors for quoting of the rates after necessary adjustments are made for transportation, inflation and profit.

The payments for extra and additional works are made after seeking approval from the Tender Committee. The deviation statement is worked out by the concerned site engineer and is counter signed by the project manager and the general manager after which it is put up to the tender committee for approval. Rates for those items not included in the original bill of quantities are analyzed by the contractor and approved by the tender committee after it has been checked and recommended by the engineering team. Site

order books are maintained by the contractors at the work site for record of any changes in the scope of the work made by visiting officials from the Government agencies. If the contractor is not able to complete the work within the stipulated time and if the delay is not justified, they are liable to pay liquidated damages which ranges from 0.01 % to 0.10% of the total contract price for each day of delay.

5. Project Control

Through personal interaction and discussion with some of the staff involved with the mass housing project, it was found that except for bar charts, they didn't have any other project control system in place. The contractor was paid as and when he/she submitted the bills and there was no check and balance system as to the expenditure. The project progress was submitted in the form of bar charts by the contractor. There were however no benchmarks and check points that are necessary for comparing the actual accomplishments to the planned ones, so that the project progress both in terms of cost and schedule can be measured, evaluated and controlled.

The objective of project control is to measure the actual values of the amount of work done with the prescribed level of quality at the predicted cost, at the end of any reporting period, and determine if the project is meeting the targets of the work plan, and to make any necessary adjustments to meet the project objectives. It is a difficult process as it involves a quantitative and qualitative evaluation of a project that is in a continuous state of changes.

The researcher would like to recommend that a control system must be developed so information can be routinely collected, verified, evaluated, and communicated to all participants in the project, so it will serve as a tool for project improvement rather than reporting flaws.

The starting point in the project control system is the development of a well defined work breakdown structure (WBS). The smallest unit in the WBS is the work packages which define the work in sufficient detail so it can be measured, budgeted, scheduled and controlled. The CPM, PERT or the RSM can then be used to develop the overall project schedule from the WBS by integrating and sequencing the work in accordance with the work packages. A coding system can be designed that identifies each component of the WBS so information from WBS can be related to the project control system. The WBS is linked with cost breakdown structure (CBS) by the code of accounts and to the organizational breakdown structure (OBS) to coordinate personnel to keep the project on schedule. The Network diagrams show the sequencing of activities that represent the work packages identified by the WBS. The expected time and cost that is required to perform each activity can be obtained from the work packages of the WBS in order to establish the parameters for control of cost and time (Oberlender, 2000).

The construction progress rate in terms of cost or percentage complete can be graphically depicted in the form of S-Curve, which is the plot of duration and the output in a straight forward and simple way. It represents the determined route of construction process, or the construction volume on one axis and time on the other. The slope of the line represents the progress rate (Fisk, 6th edition). During the actual construction process, the actual progress is compared with the scheduled graphically, from wherein the surplus or the deficit in the project progress can be easily found out.

The percent complete matrix method can be very easily used for determining the overall status of the project. It is based on the budget for each work package which can be measured as any one of the variables; cost, work hours or physical quantity of work. The percent complete matrix method requires only two input variables for each work package, estimated cost and percent complete. A spread sheet can be developed wherein the estimated cost and the percent complete for each item of the work are inputs. Formulas in the spreadsheet will then calculate the percent unit, percent project, cost to date and the

percent complete project, based on the two input data (Oberlender, 2000). Figure 20 illustrates the percent complete matrix method.

	Work package		Work Package		Work Package			
	Estimated Cost	Percent Unit	Estimated Cost	Percent Unit	Estimated Cost	Percent Unit		
	Percent Complete	Percent Project	Percent Complete	Percent Project	Percent Complete	Percent Project		
Facility								
	Cost to Date	% complete Total	Cost to Date	% complete Total	Cost to Date	% complete Total	Total Cost	Percent Total
Building								
Type I								
Building Type II								
Retaining wall								
Sewerage								
Water supply								
	Sum estimate	Percentage project	Sum estimate	Percentage project	Sum estimate	Percentage project		
	Sum cost to date	Sum % complete	Sum cost to date	Sum % complete	Sum cost to date	Sum % complete		

Figure 20 An example of the percent complete matrix for the mass housing projects.

The earned value system can also be used to monitor the work progress and compare the accomplished work with the planned work. By comparing the Budgeted Cost of Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP) and the Budgeted Cost of Work Performed (BCWP), the cost and schedule variances can be worked out. Also the cost performance Index and Schedule Performance can be calculated. From the above calculations it can be determined whether the project is progressing as per plan, or there is cost overrun and schedule delay.

For all the above project control system recommended, it requires a well defined work breakdown structure and a detailed project schedule. It is only effective if the cost and schedule data are reported in timely manner. Therefore it is of great importance that a work breakdown structure with detailed schedule is prepared before the start of the construction, and timely reporting is done in the process of the construction.

6. Project Performance

In keeping with NHDC's overall objective "to facilitate the provision of safe, adequate and affordable housing supply in the country, especially to the growing numbers of low income groups and thereby to improve the overall socio-economic and environmental conditions of the people and their surroundings", the following mass housing constructions along with the infrastructure works were carried out at Changjiji, and various other districts as detailed in table 11 and 12. Four different types of buildings were built in Changjiji, Type I is 3 storied structures with 12 units, Type I(B) 2 storied with 8 units, Type II is 3 storied with 9 units, Type III is 3 storied with 4 commercial units on the 1st floor and other 4 residential units. The District housing consist of 3 storied buildings with 6 units per building and two storied with 4 units per building. The buildings are all reinforced concrete structures, which were built at site, except for the door and window components which were prefabricated units. The details of the building area and area of one unit are as given in table 10.

Table 10 Area Details

Sl No	Description	Building Area	Area of a unit	No of Units /Bldg	Remarks
1	Type I	383.06 sqm	48.93 sqm	12	Three storied
2	Type I (B)	395 sqm	51.01 sqm	8	Two storied
3	Type II	207.84 sqm	49.45 sqm	9	Three storied
4	Type III				Three storied
	Residence	151.55 sqm	58.03 sqm	4	
	Shops		6.58 sqm	4	
5	District Housing	160.19 sqm	58.8 sqm	6	Three storied
		160.19 sqm	58.8 sqm	4	Two storied

The estimated amount, contractors quoted amount, the final amount, the start date and the completion date of each works are as given in the tables Appendix A1, A2, A3 and A4. The percentage cost difference between the quoted and the estimated amount, cost difference between the actual and quoted amount and the schedule difference between the actual and contracted duration are as illustrated in table 11 and 12. The cost and schedule performance are discussed further in detail in tables 14 and 15.

Table 11 Changjiji Housing Project cost and schedule performance

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual – Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (Days) (3)
A	**Phase I**			
1	Type I Buildings (10 numbers)			
	4 bldg	(18)	3,302,747.13	270 days
	3 bldg	(18)	1,606,344.90	251 days
	3 bldg	(18)	1,288,808.90	268 days
2	Site development works	10	718,152.30	(30 days)
3	Site development works	(28)	(42,867.61)	-
4	ext. water supply	(18)	(470.40)	-
5	Sewerage	(35)	2,234,270.38	-
6	Access road	(93)	198,211.10	-
	TOTAL		**9,305,196.70**	
B	**Phase –II buildings**			
1	Type - I Building(24 Buildings)			
	7 bldgs	(9)	10,217,680.43	427 days
	5 bldgs	49	(8,826,285.61)	338 days
	5 bldgs	13	3,805,614.76	218 days
	2 bldgs	49	(2,859,166.70)	432 day
	5 bldgs	49	(7,030,599.60)	
2	Type-II Building(20 Buildings)			
	2 bldg	(33)	2,479,786.17	268 days
	3 bldg	(33)	1,528,582.20	528 days

Table 11 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual – Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (Days) (3)
	3 bldgs	(33)	2,809,323.67	116 days
	8 bldgs	(33)	7,492,191.83	487 days
	4 bldgs	(33)	2,690,370.13	137 days
3	water supply to bldg	42	41,770.19	-
4	Construction of LV UG lines	(36)	(321,597.00)	(30 days)
5	External Water supply scheme	(15)	877,334.41	-
6	Retaining walls	(43)	(175,547.18)	-
7	Sewerage scheme	(27)	304,123.82	-
8	Storm water & house hold drain	(2)	(301,642.11)	-
9	RCC culvert and slab	-	36,904.18	-
10	Gabion Wall	-	(924,409.08)	-
11	Access road and road side drain	(35)	(85,901.50)	38 days
	Total		**11,758,533.01**	
C	**Phase III**			
1	Construction of Type-I(B) buildings, 5 blocks	13	(1,600,162.73)	-
2	Construction of Type-III bldg,6 block	15	(6,679,603.34)	-

Table 11 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual – Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (Days) (3)
3	Construction of Type-III buildings, 6 blocks	15	(6,453,558.34)	-
4	Window Safety grills, Type-I	(40)	-	122 days
5	Window Safety grills, Type-II	(26)	-	122 days
6	Internal Roads (2.1 km)	(11)	(822,477.29)	-
7	Street Lighting	(9)	174,750.00	(30 days)
8	Realignment of waste water pipe	2	(26,544.82)	-
9	Parking, RW, Footpath & Drains	(27)	(5,657,687.53)	107 days
10	Installation of Water Meter	(2)	(60,861.51)	42 days
11	2 nos of care taker's house	4	59,191.47	-
12	Public Toilet	(14)	(179,556.08)	-
13	Submersible Pump	1	(16,081.46)	60 days
14	Plaza	(22)	180,070.47	-
15	Bypass road	(23)	48,598.79	-

Table 11 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated]	Cost Differences (Actual – Tendered) (Nu)	Schedule Differences (Actual - Contract) (Days)
		(1)	(2)	(3)
	TOTAL		**(21,033,922.37)**	
	TOTAL PROJECT		**29,807.34**	

Note: Figure in ( ), depicts below estimated amount for (1), cost savings (2) and ahead of schedule (3) and – (dash) no difference

Table 12 District Housing Project cost and schedule performance

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
A	**Phase - I**			
1	2 Blocks at Trashigang	5	(2,247,426.91)	-
2	2 Blocks at Dagana	7	(1,549,267.03)	-
3	2 Blocks at Zhemgang	12	(1,899,365.14)	-
4	2 Blocks at Trongsa	1	(592,639.44)	161 days
5	2 Blocks at Trongsa	1	(820,761.26)	111 days
B	**Phase - II**			
1	4 Blocks at Trashigang	(1)	(5,484,759.34)	-
2	4 Blocks at Trashigang	(1)	(4,578,311.40)	-
3	5 Blocks at Lhuntshe	(10)	(6,218,500.08)	-
4	4 Blocks at Zhemgang	(7)	(3,192,324.49)	-
5	3 Blocks at Dagana	(20)	(3,341,574.55)	-
6	3 Blocks at Trashi Yangtse	2	(1,446,782.17)	-
7	3 Blocks at Trashi Yangtse	2	(1,384,014.12)	-
	TOTAL		**(25,646,266.15)**	
C	**Phase – III**			
1	7 Blocks at S/Jongkhar	(27)	(3,576,655.18)	-
2	4 Blocks at Bangtar	(6)	(3,358,478.80)	-
3	3 Blocks at Daifam	(7)	(1,997,617.84)	277 days
	TOTAL		**(8,932,751.82)**	

Table 12 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
D	**Phase – IV**			
1	2 Blocks at S/Jongkhar	(6)	(2,911,598.36)	
E	**Phase – V**			
1	1 Block at Dagana	(15)	(522,730.38)	-
F	**INFRASTRUCTURE WORKS**			
1	External WS, electrification & RW Works at Dagana	(5)	(104,535.54)	20 days
2	External WS & electrification Works at Zhemgang	(17)	(94,097.86)	-
3	External Water Supply Works at Trashigang	(17)	(177,860.94)	-
4	External elect. works at Trashigang	(21)	(93,667.10)	-
5	External WS & electrification works at T/Yangtse	(4)	(119,390.66)	-
6	External WS & elect. works at Trongsa	69	(53,326.24)	-

Table 12 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
7	External water supply & elect. works at Lhuntse	31	145,054.25	-
8	Construction of RW at Lhuntse	(4)	86,113.50	-
	TOTAL		**(411,710.59)**	
G	**SITE DEVELOPMENT WORKS**			
1	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trashigang Pac- I	(13)	588,185.19	-
2	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trashigang Pac- II	(10)	532,003.36	-
3	Site development works (footpath, storm water drain, parking, approach roads and RW) at Lhuntse	7	587,987.46	-

Table 12 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
4	Site development works (footpath, storm water drain, parking, approach roads and RW) at Zhemgang	(12)	(697,476.93)	-
5	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trongsa	(22)	(95,749.13)	-
6	Site development works (footpath, storm water drain, parking, approach roads and RW) at Yangtse	(40)	107,637.46	-
7	Site development works (footpath, storm water drain, parking, approach roads and RW) at Dagana	28	(142,763.20)	-

Table 12 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
H	**EXTERNAL WATER SUPPLY AND ELECTRIFICATION WORKS**			
1	External water supply and elect. works at S/jongkhar	11	(82,837.78)	-
2	External water supply and elect. works at Daifam	17	(62,462.08)	-
3	External water supply and elect. works at Bangtar	14	(1,205,472.68)	-
I	**SITE DEVELOPMENT WORKS**			
1	C/o Parking, Roads, RW and drainage works at S/Jongkhar	(2)	437,754.11	-
2	C/o Parking, Roads, RW and drainage works at Daifam	(18)	62,113.65	-
3	C/o Parking, Roads, RW and drainage works at Bangtar	7	(212,608.07)	-

Table 12 (Continued)

Sl. No	Description of Work	% Cost Difference [(Tendered-Estimated) /Estimated] (1)	Cost Differences (Actual - Tendered) (Nu) (2)	Schedule Differences (Actual - Contract) (3)
	TOTAL		**287,259.69**	

Note: Figure in ( ), depicts below estimated amount for (1), cost savings (2) and ahead of schedule (3) and – (dash) no difference

Project performance is normally measured in terms of quality, cost and schedule. A successful project means that the project has accomplished its technical performance, maintained its schedule and remained within its budgetary cost. However, it is seldom that the projects are completed within the stipulated time and budget, because of numerous unforeseen factors encountered during the construction phase of the project.

6.1 Quality

The quality of a construction depends on the completeness and quality of the contract documents that are prepared by the designer and three other factors: laborers who have the necessary skill to produce the work, field supervisors who have the ability to coordinate numerous activities that are required to construct the project in the field and quality of the materials that are used for the construction. Skilled laborers and effective management of the skilled laborers are both required to achieve a quality project (Oberlender 2000)

42 different contracts were awarded to various contractors for the Changjiji housing project, inclusive of all the buildings, site development and infrastructure works. Table 13 shows the cost comparison between the contractor quotes and the estimated amount. One of the contractors had quoted as low as 93 % below the estimated amount for the Changjiji housing and for the district the lowest quoted was 40 % below the departmental estimate.

Table 13 Comparison of contractor quotes with estimate

Project	Total Contracts	Nos. below Estimate (%)	Nos. above Estimate (%)	Same (%)
Changjiji	42	28(67%)	12(28 %)	2(5%)
District	38	23(60.5%)	15(39.5%)	-

From the personal experience of the researcher, it has been seen that the contractors in Bhutan usually quote very low in order to get the contract works, which has a negative impact on the project. It has also been mentioned by the respondents of the questionnaires, as being a problem area. They use substandard materials which are not as specified in the agreement to make more profit. With only limited availability of material testing facility in the country, it is often difficult to ascertain the genuineness of the materials used. Also there are no strict specifications of construction material standard, giving the contractors opportunity to substitute the original goods with counterfeit and imitation brands leading to compromise on the quality of construction. So it could possibly be one of the reasons for the quality problems in the housing project.

As already mentioned in the statement of problems, quality had been a big issue in the Changjiji housing project especially in the Phase I, the major among them being:

a. Cracks in the plinth protection and walls

It is felt that the major cracks in the plinth protection and the walls had been formed because of the ground settlement. It could have been prevented if proper study had been carried out of the underground soil and water conditions, before start of the design. However, the department was given very less time for planning and design, and without the required expertise sub-soil investigations could not be carried out. One of the other reasons could be because of the lack of curing. There was insufficient water in the construction site and usually it has been found that unless monitored regularly contractors tend to forgo or minimize curing in order to save cost and time.

b. Leakage in the toilet duct and walls

One of the major problems has been in the leakage of the toilet duct and the walls. It has been seen in many of the residences that portions of the walls are always wet due to water leakages, which could possibly be from the joints in the water pipe. Also the toilet ducts always have water dropping through it whenever there is supply of water. These entire leakage problems could be because of the workmanship, and use of substandard materials and not following the work specifications. The contractors are contractually and morally responsible to adhere to specification and quality, but they seldom do that with a view to earn maximum profit. Market surveys confirmed that most of the plumbing and electrical materials under a particular brand name did not have standard IS codes and counterfeit goods are sold openly (Ninth Plan Document). The site management team from NHDC could possibly have prevented these problems with regular and strict inspection and monitoring. However, NHDC has been facing a serious shortage of staff both in terms of quantity and quality. There is presently an overall shortage of more than 50% of the required numbers of staff, while most of the available staffs have limited work experience and trainings. Hence the corporation has to engage

the limited number of staff with limited experience and exposures resulting in the problem stated above.

c. Roof leakage.

As already mentioned in the statement of problems, roof tiles were used for roofing in the Phase I and II at Changjiji. The roof tiles were manufactured by some local company, and being new in business they had little expertise in that field thereby leading to quality problems. Most of the tiles are found broken due to the climatic changes, and are also blown away/shifted by the winds. This has led to the leakage of the roof during rainy seasons. It is found that it is very difficult to replace the tiles as it breaks on the weight of the workers. The company is also now closed down. There is proposal to replace all those tiles with Corrugated Galvanized Iron sheets, but it's working out too expensive for the corporation, so it has been shelved for the time being.

The Government's initiative on promoting of local industries is a noble cause and is a necessity for a developing country like Bhutan but equally important is the check on the quality of the manufactured goods. The researcher feels that it should be made mandatory for all the local industries to follow certain code of practice and to be certified by the ISO, thus preventing the problems as was faced in the Changjiji housing project.

d. Drinking water problem

Water had been a problem since the start of the construction and is still upto a certain degree, though is not as severe as it was before. Previously, the residences used to get water only once in a day for about an hour and that too only in the 1st floor. Most of the buildings constructed are 3 stories. So the other two floors had to take the water manually from down stairs, which had led to many disputes and problems. The water problem could be because of poor planning as the water tank built for storage is of under

capacity and finishes off in an hour or two, poor plumbing design as the water cannot flow up to the 2nd and 3rd floors, poor workmanship resulting to numerous leakage problems, and use of local made HDPE pipes for external water supply. The HDPE pipes do not have factory made fittings and have to be made at site which are crude and of poor workmanship. This resulted to loss of water due to leakage from the joints, thereby resulting in loss of force and the water could not flow to the upper floors. The NHDC is in the process of replacing the HDPE pipes with the GI pipes and it is found that the water problem has been reduced to a great extend. Also they have bought additional storage tanks to be installed shortly, by which it is expected that the water shortage and leakage problem will be greatly reduced.

It can be seen from the above that if proper planning, study and design had been carried out then there would not have been water problem, and also the previous expenditure for the external water supply would not have been wastage of the Government resources. The researcher would like to stress here once more that planning and study of the requirements of the project is imperative before start of any project, for a successful project.

e. Workmanship

Bhutanese construction industry is in a developing stage, and the contractors are poorly equipped in terms of both knowledge and infrastructures, which severely affect the construction project performances. This plight is further aggravated by the shortage of local human resources which is due to the reluctance of the younger generation to work as a blue collar employee especially in the construction sector. The Government has set up vocational training institutes within the country, but still a good proportion of the construction workers are imported from India the neighboring country, due to the limited capacity of the training institutes. The works are therefore carried out by the foreign semi skilled or unskilled laborers, and in the absence of any certification

procedures for the employment of the required skills, the quality of most contract works are determined by the outputs of these unskilled/semiskilled workers. Like all other construction works in Bhutan the mass housing was also carried out by the foreign workers, thereby leading to poor workmanship and many of the quality problems stated above.

6.1.1 Quality Management

Planning and controlling standards for quality are fundamental in both the design and construction phase of a project. Quality assurance is a broader more nearly all encompassing term for the application of standards and procedures to ensure that the desired performance criteria is met or exceeded, and documentations to verify the results are obtained. It involves economic studies to select the types of materials and methods to be included in design, making certain that the design is in accordance with all applicable building codes and other regulations, and controlling the construction to be sure that the works are performed according to the standards specified in the contract.

Quality control is the inspection and testing of the materials and workmanship to see that the work meets the requirements of the drawings and specification. Quality is the responsibility of all the participants in a project. The actual quality of the construction depends largely upon the control of the construction itself, which is the principal responsibility of the contractor. The goal of the contractor should be to finish the project they can be proud of and that meets the specification and satisfies the owner, and not just to get past the inspection (Oberlender 2000).

Quality control plans have to be developed prior to initiating actual construction to document the quality control organization and procedures to be used on the project. It should be made mandatory for the contractors to submit the quality control plans before the start of the construction, which should be project specific and identifies

quality control systems for each major work packages. To achieve quality in the completed project, the contractors must see that the systems are in place to assure that quality materials are procured and received, qualified workers are selected and all workmanships meets or exceeds contract requirements.

Qualified inspectors should be selected and trained to ensure that all the works performed meets contract specifications. It is the responsibility of the inspector to conduct inspections to ensure workmanships that meets quality standards, and dimensional requirements. Daily follow up inspections should be conducted to ensure continuing compliance with contract requirements. The engineers/designers from the owner's side should also visit the site throughout the construction period to ensure that all works are inspected prior to being covered, and there are no costly reworks.

6.2 Cost

The cost performances of the works carried out at Changjiji and the District housing are given in table 14. The total cost overrun for Phase I, Changjiji amounted to Nu. 9,305,196.70. In Phase II total cost overrun was Nu. 11,758,533.01, and there was cost saving of Nu. 21,033,922.37 in the third phase. In the district housing there was a cost saving of Nu. 42,283,876.98. The cost performance of the district housing was therefore better compared to the Changjiji housing.

Table 14 Cost Performance

Project	Total Contracts	Nos. Cost Overrun (%)	Nos. Cost Saving (%)	Same (%)
Changjiji				
Phase I	8	6(75%)	2(28%)	-
Phase II	19	11(58%)	8(42%)	-
Phase III	15	4(27%)	9(60%)	2(13%)
District				-
Phase I	5	-	5(100%)	-
Phase II	7	-	7(100%)	-
Phase III	3	-	3(100%)	-
Phase IV	1	-	1(100%)	-
Phase V	1	-	1(100%)	-
Infrastructure and site development works	21	8(38%)	13(62%)	-

Kinley *et al* (2007) had found that five major causes of cost overruns in Bhutan are the additional works given during construction that was not foreseen during bid preparation, reasons that yield construction delays, increase in wages, increase in material prices and interference from top level management resulting in substantial changes to the original scope of works.

Additional works during construction that was not foreseen was found to be the most important factor, and it holds true for the mass housing also. It could mean that there is lack of proper site investigation and planning in the execution of building projects in Bhutan. In construction of the Phase I buildings, huge amount of additional cost was incurred for the additional foundation/plinth wall that had to be built due to the site condition and ground slope. If proper planning and site investigation had been done before start of the work, additional work could have been avoided or would have been minimal.

Unexpected subsurface condition could be one of the reasons for the increase in cost. Without any subsurface investigation being carried out, there is bound to be some difference in the subsurface condition thereby leading to changes during construction. For the site development works, the increase in cost was because of the difference of the pay quantities as the original worked out quantities differed from the finally constructed one due to the site and subsurface conditions.

Factors that yield construction delays have also been one of the reasons for the cost overrun. The delay in handover of the site to the contractor and delay in the supply of the prefabricated door and window components by the owner led to the delay in the whole project. These delays led to the cost overrun.

As per the respondents of the questionnaire, there was no interference from the top level management leading to the change in the original scope of work. However, the researcher, from past experiences has seen that this factor has a very high impact on the cost overruns in construction projects in Bhutan which has also been substantiated by the research of Kinley *et al* (2007). It is felt that because of the sensitive nature of the question, the respondents had answered likewise. Interference from the top level not only results in substantial changes to the original scope of the work but also results in delayed completion of the project which in turn accounts for cost overrun.

6.3 Delay

Table 15 illustrates the schedule performances of the mass housing project. Overall the Changjiji Housing project as per the plan should have been completed by June 2006, but still some infrastructure works are yet to be taken over from the contractor due to the rectification of the defects. In the District housing all the planned works have been completed by June 2008. It is also seen that almost all delays were in the construction of the buildings. One of the reasons could be because of the fairly new and

inexperienced contractors who are poorly equipped in terms of both knowledge and infrastructures.

Table 15 Schedule Performance

Project	Total Contracts	Nos. delayed (%)	Nos. ahead of schedule (%)	Nos. on schedule (%)
Changjiji				
Phase I	8	3(37.5%)	1(12.5%)	4(50%)
Phase II	19	11(58%)	1(5%)	7(37%)
Phase III	15	5(33%)	1(7%)	9(60%)
District				
Phase I	5	2(40%)	-	3(60%)
Phase II	7	-	-	7(100%)
Phase III	3	1(33%)	-	2(67%)
Phase IV	1	-	-	1(100%)
Phase V	1	-	-	1(100%)
Infrastructure and site development works	21	1(5%)		20(95%)

The reasons for the delay in the constructions from the perspective of the researcher are as follows:

a. Poor Planning and Scheduling (Owner and Contractor)

Bhutanese construction industry is fairly new and both the contractors and the engineering team from the owner's side have limited technical knowledge in terms of management, not having been trained in construction management. As per the response on the questionnaires, they have mentioned that they did not have any training in construction management. The contractor engineers are also usually found not much experienced in the management aspect. The NHDC team was not given enough time for proper and effective planning. Kinley *et al* (2007), in his research, had found that this

factor was considered to be the second most important factor leading to project delay. The following problems were therefore faced which led to the delay in the project completion time.

1. The ground cutting and developmental works of the construction plots were carried out departmentally by the Department of Urban Development and Engineering Services, who was responsible for the housing during the starting of the housing project. Simultaneously, the building works were contracted out to different contractors. This led to the delay in handover of the site to the contractors, thereby leading to delays.

2. As per the agreement, the door and window components of the buildings were supplied by the Government to the construction contractors. The components, however, could not be supplied on time most of the times due to poor planning, leading to project delays.

3. Poor planning from the owner's side could also be noticed in the site development and infrastructure works leading to the delays. Different works were contracted out to different contractors, the work site sometimes passing from the same site. One contractor would therefore be in the way of another and they could not carry out the works unless one of them complete, resulting to delays.

4. The key to a successful project is good planning. However, the contractors in Bhutan do not plan or schedule the works properly, which could be due to the lack of qualified personnel in the contractors' organization, leading to delays.

b. Ineffective enforcement of the delay penalties

The contract clause states the penalty to be levied to the contractor on an event of delay, but it is not enforced effectively. Bhutan being a small country, almost

everybody knows each other and interpersonal relation usually outweighs the enforcement of contract clause. The penalties are either waved off after justification from the contractor, or just marginally penalized.

c. Delay of payments by owner

Due to the long bureaucratic process in the Government organization, there were delays in the payment of running bills to the contractors, which resulted to the problem in the contractors' cash flow. As a result, there was delay in the procurement of materials, payment of the workers, and rented equipments, thereby ultimately leading to the delay in the whole project.

d. Lack of incentives for contractors completing the work earlier than scheduled

In the mass housing project there was no clause as to give bonus to the contractor finishing the works earlier than scheduled. It is felt that if this clause is incorporated, it would motivate the contractors to finish as early as possible, thereby minimizing project delays.

e. Contractors cash flow problem

The cash flow problems of the contractors have a very severe affect in implementing the project smoothly. With financial problems, the contractors are not able to pay the suppliers, workers and the equipment owners in time, having a negative impact on the project performance, and also leading to delays. In the housing projects, few of the contractors had financial problems resulting to delays.

f. Rework due to mistakes during construction.

As has already been mentioned earlier, the construction workers in Bhutan are mainly semi skilled/unskilled foreign laborers and they tend to make a lot of mistakes during construction, which could also be because of the lack of experience and training of the technical staff of the contractors. The works therefore have to be redone, contributing to the project delay.

g. Inadequate contract duration

The construction duration in Bhutan is fixed based on the individuals experience on similar nature of work and location, and is being fixed randomly at the discretion of the planner/designer. In the mass housing project it has been responded by all except for one that the original duration provided was adequate for the completion of the project. However, the researcher feels that it could have been biased as the questionnaires were all filled up from the owners' side.

h. Shortage of workers

Almost all the construction workforces in Bhutan are imported from India. However, due to the strict labor regulation, it is not easy for the construction sector to recruit imported laborers in required quantity. Therefore the works have been carried out by fewer work forces than required. Construction industry in Bhutan is still labor intensive and without the required numbers the construction projects were delayed.

7. Communication

Communication means acquiring and transmitting information, and is the most critical project management tool. A good technical project manager who knows how to

estimate, plan, schedule and execute most likely will fail unless he or she also had good communication skills. Unless the project manager can communicate his or her needs, wants and expectations, they probably will be unfulfilled. The project manager is responsible for continuous and comprehensive flow of information to and from team members, with special attention to communicating information and decisions that may influence the project team's work. Effective written communications are essential. Most people have short memories and often hear what they want to hear, and may interpret the same communications differently. So it is necessary to make a written record of the discussions affecting a project (Schaufelberger and Holm, 2002)

For timely and efficient information exchange, and direct communication, project meetings must be held. This allows the parties involved to take appropriate action and make decisions necessary to maintain the scheduled flow of work. The schedule for the regular team meetings should be defined at the beginning of the project as a part of the project work plan. Minutes of the meeting should be recorded. Preferably the meetings should be held weekly and on the same day and time. In the mass housing project as per the responses on the questionnaire the meetings were held monthly.

8. Disputes and Resolutions

Due to the nature of the construction projects, it is almost certain that owners, contractors and designers will be involved in disputes. The disputes typically results due to the following reasons (this list is not exhaustive):

- Changes in the scope of the work during construction.
- Defective or deficient construction.
- Construction is not conformed to the specification.
- Differing site conditions.

- Additional work during construction
- Weather

Likewise the housing projects also had disputes. The disputes were mainly due to difference in specification of the materials provided during construction. The contractors with a view to earn maximum profit possible tended to use substandard materials, which was not as per the specification. Sometimes due to poor workmanship, works had to be redone, which were causes of disputes. Another cause of dispute was the absence or inadequate engineers from the contractor's side. Although in accordance to the Construction Development Board (CDB) rules, the contractors are mandated to possess certain construction equipments and human resources, there are many of them who do not have the required equipments and human resources. The causes of disputes discussed herein are only from the owner's side and the contractor's view has not been covered.

Of the several methods of dispute resolution in the construction industry which are negotiation, mediation, arbitration and litigation, the dispute in the housing project was resolved through negotiation mostly by discussing in the monthly progress meeting, and also through discussion among the contractor, owner site engineer and the project manager.

Problems Faced and Needed Areas of Improvement

Problems

The problems faced during the construction of the mass housing for the low income group as per the responses on the questionnaires are:

1. Less time for planning and design resulting to the problems in quality, cost overruns and schedule slippage as already discussed earlier.

2. Rush towards the end of financial year, so that the budget allocated for that particular activity is expended before the closure of the financial year, resulting to poor performances in the work.

3. Difficulty in maintaining the sequence of construction in absence of qualified and experienced personnel from owner and contractor side, inadequate planning and lack of scheduling before the start of construction.

4. Use of local materials resulting to quality issues as already discussed.

5. Use of unskilled and semiskilled laborers leading to poor workmanship and delays from reworks.

6. Inadequate number of laborers at the construction site resulting to slow progress of the work and schedule delays ultimately.

7. Poor management of materials, equipments and workers by the contractor, leading to delays.

8. Interference from the top level management resulting in problems during the monitoring of the daily activities in the construction site.

Needed Areas of Improvement

The areas required to be improved in the construction management field as per the respondents are:

1. Training

All the staffs involved in the mass housing were not trained in the construction management field. So it is required to train the staff so that all those involved in management is aware of the various management processes and steps for smooth flow of work as per the schedule, cost and quality. Quality management was a big issue in the housing project so it is required to train the staff on the various processes of quality control and quality assurance. The laborers involved in housing were also semiskilled/unskilled. The Vocational Training Institutes, under the Ministry of Labor and Human Resources should therefore train more workers, thereby reducing the numbers of imports of foreign laborers and also establish the practice of testing and certifying of the foreign laborers on their import to the country.

2. Contractors

Contractors in Bhutan are fairly new in business and are poorly equipped in knowledge, resources and experiences. So it is required for the Contractors' Association of Bhutan (CAB) to provide the necessary assistance in training the contractors and creating awareness in terms of quality and workmanship. They need to guide the contractors in healthy contract culture. The Construction Development Board (CDB) should strictly enforce the rule on the requirements of the manpower, equipments and other resources so that the contractors actually possess all the requirements for smooth flow of work. It is also required to specialize the contractors in different areas of construction field.

3. Planning

In the housing project enough time was not given for proper planning leading to the many problems discussed earlier. Proper planning is heart of the project management, and the success of the project greatly depends on planning. It has also been expressed by the respondents that enough time should be given for planning.

4. Mechanization

Bhutanese Construction Industry is largely labor intensive and the project time and quality depends on these labors. It is time now that the mechanization in construction is introduced such that the import of labor is reduced and the construction time is greatly shortened.

5. Use of locally manufactured construction materials.

It is the Government's objective to promote the use of local industries and the use of their manufactured goods, but however it was found that the goods were expensive compared to those imported from India, and also not easily available. Also the quality of the manufactured goods was doubtful as was seen in the housing projects. It is therefore required for the local materials to be made cheaper, easily available and of good quality.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Through this study an attempt has been made to study the prevailing practice of construction management in the provision of the mass housing for the low income group in Bhutan, specifically of the National Housing Development Corporation who is responsible for coordinating and implementing overall housing programs in the country and in particular for the lower income group. Thereafter construction management concepts have been proposed for management of mass housing projects in future.

It has been found through the study that NHDC used bar charts for planning and scheduling of the construction activity. The contractors submitted the work progress in the form of bar charts, but there were no bench marks and check points necessary for comparison of the actual progress with the planned ones. This led to delays in the project, poor quality of construction and also cost overrun. On the other hand it was found that the works were carried out with limited personnel both in terms of knowledge and numbers thereby compounding on the above problems.

The construction workers used were all imported semiskilled/unskilled labors and it had a negative effect on the work quality and time due to reworks of defective works. There was also problem with management of the construction site from the contractors' side, as they had little idea on management of construction projects, and also some had financial problem leading to delays.

Most of the field staffs involved in the project were not trained in construction management prior to the start of construction or during the process of construction. It is felt that due to this the staffs were not competent enough to carry out their duties effectively.

Recommendations

The following recommendations are made to improve the construction management practices of the NHDC, with a view to improve the project performances of their future endeavors.

Proper planning and scheduling tools should be implemented for all projects and enough time should be spend on the planning stage such that there are no issues related to poor and rushed planning later on. All the works involved should be scheduled and sequenced such that they can serve as a bench mark for future comparison with the actual. The various scheduling tools available which are the CPM, PERT, and RSM can be used to schedule the activities. For the mass housing it would be best to use RSM for scheduling as it ensures the continuous flow of resources from one site to another, which also determines the project duration. The project duration can therefore be reduced substantially.

There were no means to check whether the project was progressing well and would be finished on time and the cost incurred was within the budgeted limit. The S-curve which is a commonly used control system can be used for the control of the cost and time. The earned value system can also be used to monitor the work progress and compare the accomplished work with the planned work.

Pre-qualifications of the contractors though carried out for some big contract works were not carried out for the mass housing project. It is recommended that for future housing projects prequalification of the contractors should be carried out such that only those qualified and eligible contractors participate for the works.

Development in the capability of the human resources of both the owner and contractors are recommended, through regular trainings and refresher courses, such that all involved are competent enough for their jobs.

It is recommended for the NHDC to make it mandatory for the contractors to submit their quality control plans as per the specification in the contract documents, along with bill of quantities, such that it can be assured that the construction carried out is of standard quality. It then falls on the owner organization to monitor as to the compliance to the plans and specifications.

A system of testing and certifying of the skilled laborers on import from India should be introduced such that problems related to poor workmanships are resolved.

To control the factors that led to the delay and cost overruns the following recommendations should be made:

1. The construction industry in Bhutan is labor intensive. Therefore it should be allowed to import adequate numbers of laborers, as shortage of workers is one of the reasons for delays.

2. Quality of material is one of the factors causing delays and conflicts in construction projects. The concerned authorities should therefore explore the possibility on setting of standards and identification of material manufacturers in other countries. The dealers then will have to be mandated to import the construction materials from these pre-selected manufacturers or its representatives.

3. Enforcement of stringent penalties for defaulting contractors should be strictly followed. The present system of imposing marginal penalties creates precedence which adversely affects project performance. Conversely incentives should also be provided for

those contractors completing the work ahead of schedule, which would motivate the contractors to do their best.

The contract durations at present are fixed on the experiences of the concerned engineers on approximate basis. There is no basis on which to fix realistic contract duration. Therefore, it is felt that the labor and equipment productivity for different kinds of work in differing site conditions should be studied, which would assist in forecasting of realistic contract time.

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APPENDICES

Appendix A

Project profiles on Changjiji and District Housing.

Appendix Table A1 Changjiji housing contract details

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
A	**Phase I**			
1	Type I Buildings (10 numbers)			
	4 bldg	Rinson const.	23,009,164.00	12 months
	3 bldg	Rinchen const.	17,256,873.00	12 months
	3 bldg	T& K const	17,256,873.00	12 months
2	Site development works	KT const.	1,382,414.00	2 months
3	Site development works	Alpine builders	2,928,500.00	3 month
4	ext. water supply	Rinson const.	366,000.00	30 days
5	Sewerage	CeeDee const.	6,250,000.00	7 months
6	Access road	Yangkhil const.	17,152,000.00	1.5 months
B	**Phase -II buildings**			
1	Type - I Building(24 Buildings)			
	7 bldgs	Druk chogley	33,625,632.46	18 months
	5 bldgs	Singye const.	24,018,308.90	18 months
	5 bldgs	Rinson const.	24,018,308.90	18 months
	2 bldgs	Chapcha const.	9,607,323.56	18 months
	5 bldgs	Bhutan Eng. Const.	24,018,308.90	18 months
2	Type-II Building(20 Buildings)			
	2 bldg	Druk chogley	10,899,752.00	18 months
	3 bldg	Singye const.	16,349,628.00	18 months
	3 bldgs	Rinson const.	16,349,628.00	18 months
	8 bldgs	Chapcha const.	43,599,008.00	18 months
	4 bldgs	Bhutan Eng. Const.	21,799,504.00	18 months

Appendix Table A1 (Continued)

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
3	Water supply to bldg	JD construction	911,030.00	2 months
4	Construction of LV UG lines	M/s Singye	9,386,202.00	4 months
5	External Water supply scheme	YTS	1,029,100.00	4 months
6	Retaining walls	Nawang Builders	9,345,200.00	6 months
7	Sewerage scheme	Kuenzang Thinlay	5,000,443.20	7 months
8	Storm water & House hold drain	ST	1,964,395.56	4 months
9	RCC culvert and slab	ST	300,000.00	2 months
10	Gabion wall	Rinson const.(additional work)	3,548,585.19	6 months
11	access road and road side drain	Yangden Construction	14,95,700.00	5 months
C	**Phase III**			
1	Construction of Type-I(B) buildings, 5 blocks	Rinson	30,950,578.00	20 months
2	Construction of Type-III buildings, 6 blocks	Druk Choglay	31,180,060.50	20 months
3	Construction of Type-III buildings, 6 blocks	Chapcha Engg.	31,180,060.50	20 months
4	Window Safety grills,Type-I	Rabten	2,711,292.48	3 months
5	Window Safety grills,Type-II	KT	1,032,047.80	3 months

Appendix Table A1 (Continued)

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
6	Internal Roads (2.1 km)	Jabab	8,935,540.00	5 months
7	Street Lighting	Jabab	4,525,000.00	4 months
8	Realignment of waste water pipe	Aasish	626,850.00	1 month
9	Parking, RW, Footpath & Drains	Lhojong	25,442,336.00	9 months
10	Installation of Water Meter	Sonam	2,903,080.00	3 months
11	2 nos of care taker's house	Choki Norbu	848,699.53	60 days
12	Public Toilet	KNG	1,207,788.72	3 months
13	Submersible Pump	Penjor	1,930,159.62	60days
14	Plaza	Tshering Lhamo	1,466,926.98	90 days
15	Bypass road	Nippon tech	901,042.00	90 days

Appendix Table A2 District housing contract details

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
A	**Phase - I**			
1	2 Blocks at Trashigang	KC	11,913,961.12	15 months
2	2 Blocks at Dagana	Druk Penden	10,914,286.80	15 months
3	2 Blocks at Zhemgang	Rabjor	10,769,055.34	15 months
4	2 Blocks at Trongsa	GLT	12,725,620.60	15 months
5	2 Blocks at Trongsa	Tacho	12,725,620.60	15 months
B	**Phase - II**			
1	4 Blocks at Trashigang	Dhoensum	25,393,914.48	20 months
2	4 Blocks at Trashigang	East West	25,393,914.48	20 months
3	5 Blocks at Lhuntshe	Bhutan Engg. Co.	33,799,038.50	20 months
4	4 Blocks at Zhemgang	Dheden	27,815,569.36	20 months
5	3 Blocks at Dagana	JD	23,022,346.02	18 months
6	3 Blocks at Trashi Yangtse	Zeko	13,129,943.79	18 months
7	3 Blocks at Trashi Yangtse	Druk Chapchap	13,129,943.79	18 months
C	**Phase - III**			
1	7 Blocks at S/Jongkhar	Druk Choglay	36,777,006.00	20 months
2	4 Blocks at Bangtar	K.D	21,920,820.00	18 months
3	3 Blocks at Daifam	Bhutan Builders	16,783,980.00	18 months
D	**Phase - IV**			
1	2 Blocks at S/Jongkhar	Dekiling	11,612,546.00	14 months
E	**Phase - V**			
1	1 Block at Dagana	Apex	7,385,817.89	12 month

Appendix Table A2 (Continued)

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
F	**INFRASTRUCTURE WORKS**			
1	External WS, elect. & RW Works at Dagana	Samdrup	1,540,980.78	60 days
2	External WS & elect. works at Zhemgang	RJ	1,184,751.12	90days
3	External Water Supply Works at Trashigang	Tsasuu Yangthel	1,198,640.00	3 months
4	External elect. works at Trashigang	Tsasuu Yangthel	1,201,507.00	3 months
5	External WS & elect. works at T/Yangtse	Kencho Sum	763,373.21	3 months
6	External WS & elect. works at Trongsa	Ugyen Tashi	498,448.00	3 months
7	External WS & elect. works at Lhuntse	Sonam Jamtso & Bros	723,345.00	90days
8	Construction of RW at Lhuntse	Taksengchundrik	1,946,335.00	4 months
G	**SITE DEVELOPMENT WORKS**			
1	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trashigang Pac- I	Tobden	3,616,483.54	160 days

Appendix Table A2 (Continued)

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
2	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trashigang Pac- II	Tobden	3,497,623.11	160 days
3	Site development works (footpath, storm water drain, parking, approach roads and RW) at Lhuntse	Tobden	3,161,092.28	160 days
4	Site development works (footpath, storm water drain, parking, approach roads and RW) at Zhemgang	Tshering Samdrup	4,751,633.98	160days
5	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trongsa	Dorji	2,882,546.66	160 days
6	Site development works (footpath, storm water drain, parking, approach roads and RW) at Yangtse	Kharsa	3,098,312.00	4 months

Appendix Table A2 (Continued)

Sl. No	Description of Work	Contractor	Estimated Amount (Nu)	Contract Duration
7	Site development works (footpath, storm water drain, parking, approach roads and RW) at Dagana	C.D	1,715,023.00	4 months
H	**EXTERNAL WATER SUPPLY AND ELECTRIFICATION WORKS;**			
1	External water supply and elect. works at S/jongkhar	Wangyel	1,796,528.00	3 months
2	External water supply and elect. works at Daifam	Rirab	1,592,973.00	3 months
3	External water supply and elect. works at Bangtar	Rirab	3,578,954.00	4 months
I	**SITE DEVELOPMENT WORKS**			
1	C/o Parking, Roads, RW and drainage works at S/Jongkhar	Tshewang	6,775,120.00	4 months
2	C/o Parking, Roads, RW and drainage works at Daifam	Samphel	1,695,175.00	3 months
3	C/o Parking, Roads, RW and drainage works at Bangtar	Tshewang	1,683,720.00	3 months

Appendix Table A3 Changjiji housing cost and schedule details

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
A	**Phase I**				
1	Type I Buildings (10 numbers)				
	4 bldg	18,824,234.80	22,126,981.93	28-Feb-01	28-Nov-02
	3 bldg	14,118,176.10	15,724,521.00	20-Feb-01	1-Nov-02
	3 bldg	14,118,176.10	15,406,985.00	20-Feb-01	18-Nov-02
2	Site development works	1,523,000.00	2,241,152.30	5-Jun-03	6-Jul-03
3	Site development works	2,117,867.61	2,075,000.00	17-Dec-00	17-Mar-01
4	External water supply	300,470.40	300,000.00	17-Jan-03	17-Feb-03
5	Sewerage	4,032,395.00	6,266,665.38	15-Feb-01	15-Sep-01
6	Access road	1,261,788.90	1,460,000.00	11-Jan-01	26-Feb-01
	Total	**56,296,108.91**	**65,601,305.61**		
B	**Phase -II buildings**				
1	Type - I Building(24 Buildings)				
	7 bldgs	30,539,960.00	40,757,640.43	21-Dec-01	30-Aug-04
	5 bldgs	35,697,530.00	26,871,244.39	17-Jan-02	25-Jun-04
	5 bldgs	27,249,380.00	31,054,994.76	3-Mar-02	11-Apr-04
	2 bldgs	14,279,012.00	11,419,845.30	19-Dec-01	1-Sep-04
	5 bldgs	35,697,530.00	28,666,930.40	4-Jan-02	20-Nov-03
2	Type-II Building(20 Buildings)				
	2 bldg	7,261,940.42	9,741,726.59	21-Dec-01	19-Mar-04
	3 bldg	10,892,910.63	12,421,492.83	17-Jan-02	28-Dec-04
	3 bldgs	10,892,910.63	13,702,234.30	12-Feb-03	7-Dec-04

Appendix Table A3 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
	8 bldgs	29,047,761.68	36,539,953.51	19-Dec-01	19-Oct-04
	4 bldgs	14,523,880.84	17,214,250.97	4-Jan-02	20-Nov-03
3	Water supply to bldg	1,290,466.60	1,332,236.79	16-Feb-02	15-Apr-02
4	Construction of LV UG lines	5,999,921.00	5,678,324.00	1-Apr-04	1-Jul-04
5	External water supply scheme	872,665.59	1,750,000.00	1-Apr-04	31-Aug-04
6	Retaining walls	5,354,547.18	5,179,000.00	1-Apr-04	1-Oct-04
7	Sewerage scheme	3,634,672.00	3,938,795.82	16-Feb-03	16-Sep-03
8	Storm water & house hold drain	1,928,705.07	1,627,062.96	15-May-04	15-Sep-04
9	RCC culvert and slab	300,000.00	336,904.18	15-Sep-04	15-Nov-04
10	Gabion wall	3,548,585.19	2,624,176.11	8-Dec-04	7-Jun-04
11	Access road and road side drain	976,901.50	891,000.00	1-Jun-02	6-Dec-02
C	**Phase III**				
1	Construction of Type-I(B) buildings, 5 blocks	34,896,335.75	33,296,173.02	21-Nov-04	20-Jul-06

Appendix Table A3 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
2	Construction of Type-III buildings, 6 blocks	35,838,149.22	29,158,545.88	21-Nov-04	20-Jul-06
3	Construction of Type-III buildings, 6 blocks	35,838,149.22	29,384,590.88	21-Nov-04	20-Jul-06
4	Window Safety grills,Type-I	1,637,040.00	1,637,040.00	1-Feb-05	1-Sep-05
5	Window Safety grills,Type-II	766,889.53	766,889.53	1-Feb-05	1-Sep-05
5	Internal Roads (2.1 km)	7,994,735.00	7,172,257.71	1-May-05	30-Sep-05
7	Street Lighting	4,125,250.00	4,300,000.00	1-Apr-05	1-Jul-05
8	Realignment of waste water pipe	639,906.00	613,361.18	1-Jun-05	30-Jun-05
9	Parking, RW, Footpath & Drains	18,616,880.14	12,959,192.61	1-May-06	17-May-07
10	Installation of Water Meter	2,831,434.02	2,770,572.51	1-Dec-06	12-Apr-07
11	2 nos of care taker's house	885,870.26	945,061.73	14-Jun-07	13-Aug-07

Appendix Table A3 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
13	Submersible Pump	1,953,900.00	1,937,818.54	10-May-07	7-Sep-07
14	Plaza	1,139,929.53	1,320,000.00	1-Mar-08	handing taking to be done
15	Bypass road	691,401.21	740,000.00	1-Mar-08	handing taking to be done
	Total	**148,889,866.89**	**127,855,944.52**		

Appendix Table A4 District housing cost and schedule details

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
A	**Phase - I**				
1	2 Blocks at Trashigang	12,483,955.50	10,236,528.59	17-Jul-05	8-Nov-06
2	2 Blocks at Dagana	11,679,777.92	10,130,510.89	13-Jul-05	13-Oct-06
3	2 Blocks at Zhemgang	12,045,639.88	10,146,274.74	14-Jul-05	14-Oct-06
4	2 Blocks at Trongsa	12,845,369.68	12,252,730.24	17-Jul-05	26-Mar-07
5	2 Blocks at Trongsa	12,845,369.68	12,024,608.42	17-Jul-05	4-Feb-07
	TOTAL	**61,900,112.66**	**54,790,652.88**		
B	**Phase - II**				
1	4 Blocks at Trashigang	25,084,544.80	19,599,785.46	17-Jul-05	25-Jan-07
2	4 Blocks at Trashigang	25,084,544.80	20,506,233.40	17-Jul-05	15-Feb-07
3	5 Blocks at Lhuntshe	30,560,388.65	24,341,888.57	20-Sep 05	15-May-07
4	4 Blocks at Zhemgang	25,846,719.60	22,654,395.11	15-Sep-05	15-May-07
5	3 Blocks at Dagana	18,331,096.35	14,989,521.80	13-Sep-05	14-Mar-07
6	3 Blocks at Trashi Yangtse	13,437,822.21	11,991,040.04	21-Sep-05	28-Mar-07

Appendix Table A4 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
7	3 Blocks at Trashi Yangtse	13,437,822.21	12,053,808.09	21-Sep-05	28-Mar-07
	TOTAL	**151,782,938.62**	**126,136,672.47**		
C	**Phase - III**				
1	7 Blocks at S/Jongkhar	26,736,059.28	23,159,404.10	3-Dec-05	3-Jun-07
2	4 Blocks at Bangtar	20,652,112.60	17,293,633.80	6-Jan-06	5-Jul-07
3	3 Blocks at Daifam	15,638,400.33	13,640,782.49	6-Jan-06	10-Apr-08
	TOTAL	**63,026,572.21**	**54,093,820.39**		
D	**Phase - IV**				
1	2 Blocks at S/Jongkhar	10,938,360.00	8,026,761.64	25-May-06	24-Jul-07
E	**Phase - V**				
1	1 Block at Dagana	6,277,462.00	5,754,731.62	Jul-06	Jun-07
F	**INFRASTRUCTURE WORKS**				
1	External WS, elect. & RW Works at Dagana	1,471,318.12	1,366,782.58	10-Nov-06	29-Jan-07
2	External WS & elect. works at Zhemgang	986,134.40	892,036.54	4-Dec-06	27-Feb-07

Appendix Table A4 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
3	External Water Supply Works at Trashigang	989,336.40	811,475.46	23-Jan-07	16-Apr-07
4	External elect. works at Trashigang	948,588.18	854,921.08	23-Jan-07	16-Apr-07
5	External WS & elect. works at T/Yangtse	731,599.74	612,209.08	23-Jan-07	23-Apr-07
6	External WS & elect. works at Trongsa	843,016.54	789,690.30	8-Mar-07	6-May-07
7	External WS & elect. works at Lhuntse	948,588.18	1,093,642.43	5-Mar-07	4-Jun-07
8	Construction of RW at Lhuntse	1,860,222.30	1,946,335.80	26-Jan-07	25-May-07
	TOTAL	**8,778,803.86**	**8,367,093.27**		
G	**SITE DEVELOPMENT WORKS**				
1	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trashigang Pac- I	3,130,176.30	3,718,361.49	13-Nov-07	12-Apr-08

Appendix Table A4 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
2	Site development works at Trashigang Pac- II	3,146,313.40	3,678,316.76	13-Nov-07	12-Apr-08
3	Site development works (footpath, storm water drain, parking, approach roads and RW) at Lhuntse	3,367,574.35	3,955,561.81	9-Nov-07	9-Apr-08
4	Site development works (footpath, storm water drain, parking, approach roads and RW) at Zhemgang	4,190,576.48	3,493,099.55	10-Nov-07	10-Apr-08
5	Site development works (footpath, storm water drain, parking, approach roads and RW) at Trongsa.	2,251,331.99	2,155,582.86	8-Nov-07	8-Apr-08

Appendix Table A4 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
6	Site development works (footpath, storm water drain, parking, approach roads and RW) at Yangtse	1,865,221.69	1,972,859.15	12 –Nov- 07	11-Mar-08
7	Site development works (footpath, storm water drain, parking, approach roads and RW) at Dagana	2,191,636.81	2,048,873.61	6-Nov-07	6-Mar-08
H	**EXTERNAL WATER SUPPLY AND ELECTRIFICATION WORKS**				
1	External water supply and elect. works at S/jongkhar	1,993,692.92	1,910,855.14	15-Jan-08	14-Apr-08
2	External water supply and elect works at Daifam	1,860,109.95	1,797,647.87	1-Feb-08	1-May-08
3	External water supply and elect. works at Bangtar	4,086,602.25	2,881,129.57	15-Jan-08	14-May-08
	TOTAL	**7,940,405.12**	**6,589,632.58**		

Appendix Table A4 (Continued)

Sl. No	Description of Work	Tendered Amount (Nu)	Final Amount (Nu)	Start Date	Completion Date
I	**SITE DEVELOPMENT WORKS**				
1	C/o Parking, Roads, RW and drainage works at S/Jongkhar	6,669,573.62	7,107,327.73	15-Mar-08	14-May-08
2	C/o Parking, Roads, RW and drainage works at Daifam	1,385,074.35	1,447,188.00	9-Apr-08	30-Jun-08
3	C/o Parking, Roads, RW and drainage works at Bangtar	1,797,125.88	1,584,517.81	15-Mar-08	30-May-08
	TOTAL	**9,851,773.85**	**10,139,033.54**		

Appendix B

Bhutan Construction Industry

1. Present Scenario

The Construction Industry of Bhutan is still in its infancy stage. The Construction Industry covers materials which includes the local construction material production units and local dealers for imported construction materials. It also covers services including private architectures, designers and engineers, private contractors, private construction equipment dealers and private construction equipment service centers.

The Bhutanese contractors are poorly equipped in terms of both knowledge and infrastructures, and are involved in construction of only buildings, roads, and bridges which are quite simple in design and are of moderate or low budget. The complex projects like hydropower plants are executed by international contractors. Public utility facilities, like irrigation channel, rural water supply, foot bridges, mule tracks, and also monasteries, are built by the local communities, through labor contribution while materials are provided by the government.

The construction industry in Bhutan faces serious shortages of local human resources. The labor shortages are due to the small number of population in the country. This is further aggravated by many of the younger generation being reluctant to work as a blue collar employee in the private construction sector. The private construction sectors are still in a very early developing stage and therefore people are reluctant to join them, as there is no job security, they are paid low wages, there is no training opportunities, career advancement opportunities, and also post retirement benefits. Hence to overcome the shortages of workers, almost all the construction labors are imported from India. However, due to strict labor import regulation, the construction sectors are not able to import laborers in required quantity.

Only limited construction materials are available locally and except for cement, sand, stone, timber, high density polyethylene pipes (HDPE), limited quantity of

electrical wires and concrete blocks, all other construction materials are imported from India. Although some wood based manufacturers have started to produce mechanized prefabricated doors and windows, the quantity is not large enough to induce any major transformation in the construction industry. Nor is it large enough to reduce the human resource intensity in construction sites.

In a landlocked country like Bhutan, the socio-economic development of the country depends largely on an efficient and reliable road network. The long, narrow and winding roads across rugged terrain hinder the transportation of construction materials to the construction sites, especially during the rains and snows. During rains the roads are blocked by landslides and during winter by the snow.

Construction in Bhutan especially the building works are carried out by manual laborers and the use of equipment is minimal. This could be because of the unavailability of the equipment with the local equipment owners, and also most of the works carried out by the national contractors being of comparatively small budget. The equipment used in a building construction works are back hoe, excavators, portable concrete mixtures and hand vibrators. For road works the use of all the required equipment has started quiet recently.

Although the Government agencies possess a small team of engineers to oversee the engineering works, they are highly overstretched due to being less in numbers. There is shortage of engineers in the government as well as private sector. With only one undergraduate engineering college and a diploma college, the bulk of the engineers in Bhutan study outside mostly in India.

In absence of strict specifications of construction material standards, the contractors substitute original goods with counterfeit and imitation brands that compromise the quality of the construction. Market surveys carried out of four major

towns confirmed that most of the building, plumbing and electrical materials under a particular brand name did not have standard IS codes and counterfeit goods were sold openly in the hardware shops (Ninth Plan Document).

2. Agencies responsible for development of the construction industry

The various agencies responsible for the development of construction industry of Bhutan are as outlined below:

2.1 Ministry of Works and Human Settlement(MoWHS)

The Ministry of Works and Human Settlement is the leading and biggest engineering unit in the country. It was established in 2003, with one of its mandate being to set policies to promote appropriate construction industry. The two main engineering units under the ministry are the Department on Urban Development and Engineering Services (DUDES), and the Department of Roads (DOR).

2.2 Construction Development Board (CDB)

The Construction Development Board (CDB), under the MoWHS, was established in 1987 as an independent interagency representative organization of the Royal Government of Bhutan with mandate to act as promoter & overseer of construction industry and to develop an efficient & quality based construction industry within Bhutan. It is also committed to ensuring fair and equal access to the award of contracts.

The functions of CDB are registration and coordination of the architectural and engineering consultants, contractors, promote cooperation for development initiatives for quality construction industry, dispute resolution, collect and disseminate industry

information and statistics, development of manpower in cooperation with appropriate institutions and overseer of the construction industry.

Starting 1999, contractors have been registered with the CDB to streamline their eligibility for various categories of works. The Contractors are classified according to their capabilities for each category of work. There are four classifications ranging from "A" (Large) to "D" (Petty). Contractor classification determines the size of construction works that they are eligible to undertake, as well as the maximum number of contracts that can be awarded at a time. Table Appendix B1 lists the four classifications available for each category of work

Appendix Table B1 Permissible work volumes & values of Contractors

Details	A(large)	B (Medium)	C (Small)	D (Petty)
Eligible bid amount (million Nu)	>15	>7.5 & = 15	>1.5 & = 7.5	Upto 1.5
Maximum number of contracts at a time	5	3	3	1
Maximum value of contracts at a time (million Nu)	No ceiling	45	22.5	1.5

The list of contractors as of June 2008, are as depicted in Appendix B2

Appendix Table B2 List of Contractors

	District	A	B	C	D	R	Total
1	Bumthang	2	2	6	39	1	50
2	Chukha	8	3	19	112	0	142
3	Dagana	0	0	3	44	0	47
4	Gasa	0	0	0	6	0	6
5	Haa	0	0	15	66	0	81
6	Lhuntse	0	0	6	47	0	53
7	Mongar	0	1	16	107	0	124
8	Paro	1	3	16	111	0	131
9	Pemagatshel	0	0	7	43	0	50
10	Punakha	0	0	6	37	0	43
11	Samdrup Jonkhar	1	1	11	45	0	58
12	Samtse	0	0	12	72	0	84
13	Sarpang	1	0	9	72	1	83
14	Thimphu	36	15	77	367	3	498
15	Trashi Yangtse	0	0	5	87	0	92
16	Trashigang	1	2	12	133	1	149
17	Trongsa	0	0	7	50	0	57
18	Tsirang	0	0	1	42	0	43
19	Wangdue	0	0	10	83	0	93
20	Zhemgang	0	0	8	46	0	54
Total		**50**	**27**	**246**	**1609**	**6**	**1938**

2.3 Standard and Quality Control Authority(SQCA)

Recognizing the need for research on materials and construction methods, the Standards & Quality Control Division was established in January 2000, to develop construction standards and engineering code of practice. It is entrusted with the primary responsibility to develop standards and ensure quality in the construction sector. Its various functions are:

- Harmonization of standards with regional and international standards.

- Adoption of International Standards, Regional Standards or standards of other standards bodies as Bhutanese Standards.

- Compliance to code of good practice for the preparation, adoption and application of standards.

- Development of accreditation system for conformity assessment bodies and testing and calibration laboratories.

- Human resource development for efficient implementation of the vision.

- Technology development and transfer especially environmentally sound technologies.

- Awareness generation

2.4 Construction Association of Bhutan (CAB)

The Construction Association of Bhutan was institutionalized in January 25, 2000. The role of the Association is to represent as a forum for the Bhutanese construction industry and address problems and policy issues at national, regional and international level for the development and promotion of the construction industry. The main functions of CAB are:

- Keep abreast of the specific policy issues related to construction industry
- Interact with concerned agencies both within and outside the country for development and promotion of construction industry
- Promote awareness amongst the construction industry on national developmental plans and programs
- Initiate and implement developmental and promotional plans and programs for construction industry
- Provide services to members such through advice, training, development of guiding rates, dissemination of information, etc.
- Advocate private construction sector for its development and promotion both within and outside the country
- Gear the construction contractors towards strengthening of the association as a strong representative forum for construction industry's benefit, both within and outside the Kingdom.

2.5 Bhutan Chamber of Commerce and Industry (BCCI)

The BCCI was established in 1980, and is a non-profit making private sector organization, comprising of business community members from all around the country. Its main functions are:

- Facilitate and Promote Private Sector Development in Bhutan
- Provide a forum for discussion and exchanging views relevant to Private Sector development
- Function as a center for receiving and disseminating all kinds of business information related to private sector development in Bhutan
- Liaise between the Private Sector & the Royal Government
- Receive and submit the views, suggestions and recommendations of the private sector to the government on all policy matters pertaining to the private sector.

2.6 Technical Institutes

The College of Science and Technology at Rincheding, is the only institute providing undergraduate courses in civil and electrical engineering. The other institute, Jigme Namgyal Polytechnic in Dewathang provides diploma courses in Civil, Electrical and Mechanical engineering. The bulk of the engineers working in Bhutan construction industry comprises of diploma certificate holders.

Other vocational institutes including Construction Training Center at Thimphu provides training on skill development including carpentry, masonry, electrical, and

plumbing. However, bulk of the skilled workers comes from the neighboring countries mostly from India as the local produce cannot meet the market demand.

3. Contract System

Most of the public constructions projects are executed through the engagement of private contractors. Private individuals seldom award works to a contractor. The works are however given on labor contract.

The mode of payment used is the unit price contract for almost all the construction projects, except for some very small works where the works are given as lump sum contract. The estimates are prepared based on the Bhutan Schedule of Rates (BSR), and the contracts are awarded based on the quoted rates of the winning contractor.

The contract durations are fixed arbitrarily based on the individuals experience on the similar nature of work and location. Till date no research has been done to evaluate the cost time relationship in the construction industry, and there are no documented records on research carried out on the labor and equipment productivity.

The tenders are evaluated based on the standard guidelines prepared by the Standards & Quality Control Authority, MoWHS. The guideline takes into consideration the technical and financial capacity of the firm on one part and the bid amount on the other part constituting 60% and 40% respectively. The bidder who secures the maximum point is considered as the lowest evaluated bidder and is awarded the work. The bid evaluation is normally done by an evaluating committee and the recommendations are submitted to the tender committee for review and subsequent approval to award the work to the lowest evaluated bidder.

4. Project Delivery System

The design-bid-build method of project delivery system is most commonly adopted by almost all the procuring agencies. The design is done by their own designer or sometimes given to design firms, after completion of which the works are tendered out for construction.

Appendix C

Questionnaire

Name: ……..….

Designation: ……

Position:……..

Educational Qualification:……..

Construction Experience: ……..

Email: …….

Tel. No: …….

Date: …….

1. The type of organizational structure
    a. Functional Organization
    b. Projectized Organization
    c. Matrix Organization
    d. Others

2. Types of planning and scheduling tools used:
    a. CPM
    b. PERT
    c. Repetitive scheduling method.
    d. Bar chart
    e. Others

3. Project Delivery System used
    a. Traditional
    b. Turn key
        i. Design-build
        ii. Design-manager
    c. Owner- build
    d. Professional Construction Manager
        i. General Contractor
        ii. Construction Manager
    e. Others

4. Types of Construction Contract
    a. Fixed Price Contract
        i. Lump sum contract
        ii. Unit price contract
        iii. Fixed price-incentive contract

b. Cost Reimbursable Contract
    i. Cost plus percentage of cost
    ii. Cost plus fixed fee
    iii. Cost plus incentive
c. Guaranteed maximum price contract
d. Others

5. Project Control system used
    a. S-Curve
    b. Earned value system
    c. Others

Note : If select others, please specify

6. Housing Details

Details	Phase I	Phase II	Phase III	District Housing
Building type				
Year of const.				
No. of floors				
Area of bldg.				
No of units/bldg				
Area of one unit				
Number of bldg.				
Other infrastructures				
Road/Parking				
Footpath				
Drainage				
Street light				

ii. Total Cost including Infrastructure

a. Estimated :

b. Contracted:

c. Actual :

iii. Construction Duration

a. Scheduled :

b. Actual :

7. Cost and Schedule details of the housing project

S/NO	Phases of the Project	Cost (in percentage)		Schedule (in percentage)	
		Over	Under	Ahead	Delay
1	Phase I				
2	Phase II				
3	Phase III				
4	District Housing				

8. Contractor Details

Details	**Phase I**	**Phase II**	**Phase III**	**District Housing**
Name(s)/Class :				
Contract Amount :				

9. Was the original contract duration adequate for the construction and how was the duration determined. If no what could be the possible reasons.

i. Yes ii. No

……

……

……

10. Was prequalification of the prospective contractors carried out and how.

    i. Yes ii. No

……

……

……

11. Was the contractor provided incentives for finishing before the contracted period, and if yes what were the incentives.

    i. Yes ii. No

……

……

……

12. Was the scope of the project adequately defined, and clear to you. If no please explain.

    i. Yes ii. No

……

……

……

13. Was sufficient data collected, site surveyed and sub soil investigation carried out for the design of the structures. If no what could be the possible reasons.

    i. Yes ii. No

……

……

……

14. Was the design clear and adequate details provided. If no please explain.

    i.Yes ii. No

    ……

    ……

    ……

15. Were there any mistakes and discrepancies in the design documents. If yes please explain.

    i. Yes ii. No

    ……

    ……

    ……

16. Was the contractor able to mobilize enough resources (including manpower-skilled, unskilled, materials, equipments, and tools) for the project. If no please explain.

    i. Yes ii. No

    ……

    ……

    …….....

17. Did the contractor coordinate and manage all the construction activities smoothly. If no please explain.

    i. Yes ii. No

    ……

    ……

    ……

18. Was there adequate support from the top management
    i. Shares responsibility for ensuring project success
    ii. Responsive to any crises/problems/needs regarding the project
    iii. Supports your decision

19. Was there interference from the top management leading to change in the original scope of work. If yes what was its impact to the project
    i. Yes ii. No

    ……
    ……
    ……

20. Was the staffs involved in the project sufficient for smooth flow of the works (both owner and contractor sides). If no from whose side and what were the consequences.
    i. Yes ii. No

    ……
    ……
    ……

21. Was the project management team (including project manager, project engineer, site engineers, etc) trained in project management
    i. Yes ii. No

22. Was the project monitored regularly with regards to compliance to specification, cost, schedule, and how often.
    i. Yes
        1. Weekly
        2. Monthly

3. Quarterly
4. Others

ii. No

23. Was regular meeting held to monitor the project progress and improve the feedback to the project team, and how often.

i. Yes

1. Weekly
2. Monthly
3. Quarterly
4. Others

ii. No

24. Reasons for the quality problems (Contractor)

a. Knowledge
   i. Very little
   ii. Little
   iii. Average
   iv. Good
   v. Excellent
b. Workmanship
   i. Very poor
   ii. Poor
   iii. Satisfactory
   iv. Good
   v. Excellent
c. Supervision
   i. Very poor
   ii. Poor

iii. Satisfactory
iv. Good
v. Excellent

d. Site condition
e. Construction materials

25. Reasons for the quality problems (Owner)
    a. Knowledge
        i. Very little
        ii. Little
        iii. Average
        iv. Above average
        v. Excellent
    b. Inadequate staff
    c. Supervision
    d. Site condition

26. Was there any conflict with the construction contractors and if yes please specify. How was it resolved.

27. Any other problems encountered during the construction of the housing and reasons for the problems, if any.

28. Needed areas of improvement in the construction management field.

Appendix D

Results of Questionnaires

Appendix Table D1 Results of Questionnaire

Sl No	Details	Respondents							
		1	2	3	4	5	6	7	8
1	Type of Organizational Structure								
1.1	Functional Organization	✓	✓	✓			✓	✓	
1.2	Projectized Organization				✓	✓			✓
1.3	Matrix Organization								
1.4	Others								
2	Type and Planning and Scheduling tools used								
2.1	CPM	✓	✓	✓			✓		
2.2	PERT	✓	✓						
2.3	Repetitive Scheduling Method				✓			✓	
2.4	Bar Chart	✓	✓			✓			✓
2.5	Others								
3	Project Delivery system used								
3.1	Traditional (Design/Bid/Build)	✓							
3.2	Turn key								

Appendix Table D1 (continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
3.2.1	Design-Build		✓						
3.2.2	Design-Manager								
3.3	Owner-Build								
3.4	Professional Construction Manager					✓		✓	✓
3.4.1	General Contractor	✓		✓	✓		✓		
3.4.2	Construction Manager								
3.5	Others								
4	Types of construction contract								
4.1	Fixed Price Contract					✓			✓
4.1.1	Lump sum contract								
4.1.2	Unit price contract	✓	✓	✓			✓		
4.1.3	Fixed price-incentive contract								
4.2	Cost Reimbursable Contract								
4.2.1	Cost plus percentage of cost								
4.2.2	Cost plus fixed fee								
4.2.3	Cost plus incentive								

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
4.3	Guaranteed maximum price contract				✓			✓	
4.4	Others								
5	Project Control System used								
5.1	S-Curve	✓			✓			✓	
5.2	Earned-Value System					✓			✓
5.3	Others		✓	✓			✓		
6	Was the original contract duration adequate for construction and how was the duration determined. If no what could be the possible reasons	Yes	Yes	Yes	Yes	Yes/No	Yes	No	No
7	Was prequalification of the prospective contractors carried out and how	No	-	No	-	Yes	No	No	No
8	Was the contractor provided incentives for finishing before the contracted period, and if yes what were the incentives.	No	No	No	No	No	No	No	No

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
9	Was the scope of the project adequately defined, and clear to you. If no please explain.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	Was sufficient data collected, site surveyed and sub soil investigation carried out for the design of the structures. If no what could be the possible reasons.	Yes	Yes	No	Yes	Yes	No	No	No
11	Was the design clear and adequate details provided. If no please explain.	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
12	Were there any mistakes and discrepancies in the design documents. If yes please explain.	No	No	No	No	No	Yes	Yes	Yes
13	Was the contractor able to mobilize enough resources (including manpower- skilled, unskilled, materials, equipments, tools) for the project. If no please explain.	Yes	Yes	Yes	Yes	Yes/No	Yes	Yes	No

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
14	Did the contractor coordinate and manage all the construction activities smoothly. If no please explain.	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
15	Was there adequate support from the top management								
15.1	Shares responsibility for ensuring project success	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes
15.2	Responsive to any crises/problems/needs regarding the project	Yes	Yes	-	-	-	Yes	Yes	Yes
15.3	Supports your decision	Yes	Yes	Yes	-	-	Yes	Yes	Yes
16	Was there interference from the top management leading to change in the original scope of work. If yes what was its impact to the project	No	No	No	No	No	No	No	No

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
17	Was the staffs involved in the project sufficient for smooth flow of the works (both owner and contractor sides). If no from whose side and what were the consequences.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18	Was the project management team (incl. project manager, project eng. site engineers, etc) trained in project management	No	No	Yes	No	No	Yes	No	No
19	Was the project monitored regularly with regards to compliance to specification, cost, schedule, and how often.								
19.1	Weekly				✓	✓		✓	✓
19.2	Monthly	✓	✓	✓			✓		
19.3	Quarterly								
19.4	Others								
19.5	No								

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
20	Was regular meeting held to monitor the project progress and improve the feedback to the project team, and how often.								
20.1	Weekly					✓		✓	✓
20.2	Monthly		✓	✓	✓		✓		
20.3	Quarterly	✓							
20.4	Others								
20.5	No								
21	Reasons for the quality problems(Contractor)								
21.1	Knowledge								
21.1.1	Very Little								
21.1.2	Little								
21.1.3	Average	✓				✓			✓
21.1.4	Good		✓	✓			✓	✓	
21.1.5	Excellent				✓				

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
21.2	Workmanship								
21.2.1	Very poor								
21.2.2	Poor								
21.2.3	Satisfactory	✓			✓		✓	✓	✓
21.2.4	Good		✓			✓			
21.2.5	Excellent								
21.3	Supervision								
21.3.1	Very poor								
21.3.2	Poor								
21.3.3	Satisfactory	✓	✓	✓	✓		✓	✓	
21.3.4	Good					✓			✓
21.3.5	Excellent								
21.4	Site Condition					✓		✓	
21.5	Construction materials					✓			
22	Reasons for the quality problems (Owner)								

Appendix Table D1 (Continued)

Sl. No	Details	Respondents							
		1	2	3	4	5	6	7	8
22.1	Knowledge								
22.1.1	Very Little								
22.1.2	Little								
22.1.3	Average	✓	✓			✓	✓	✓	✓
22.1.4	Good								
22.1.5	Excellent								
22.2	Inadequate staff	✓			✓		✓		
22.3	Supervision		✓	✓		✓	✓		
22.4	Site Condition	✓				✓	✓	✓	✓

CURRICULUM VITAE

NAME : Mrs. Chane Zangmo

BIRTH DATE : February 13, 1973

BIRTH PLACE : Thimphu, Bhutan

EDUCATION :

YEAR	INSTITUTE	DEGREE/DIPLOMA
1998	Sardar Vallabhai Regional College of Eng. and Technology, India	Bachelor of Engineering (Civil Engineering)
2009	Kasetsart University Bangkok, Thailand	Masters in Engineering. (Civil Engineering)

POSITION/TITLE : Dy. Executive Engineer

WORK PLACE : District Administration, Paro, Bhutan