Doctor of Philosophy

Effects of Preconstruction Activities on Net Promoter Score

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by

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Abstract

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Owner, designer, constructor, and other construction stakeholders put every effort into the project for its success but it is not easy to achieve project success. A number of projects fail to achieve project goals and end up exceeding cost and having schedule delays. Therefore, cases of customer’s mistrust and dissatisfaction have increased.

This research attempts to prove the fact that the PreConstruction Activities (PCA), which are composed of the predesign, design and procurement phase of the 5 stages in the construction project lifecycle, significantly contribute to the project’s success as well as acquire loyal customers.

PCA is to review the goals (cost, schedule, and quality) established during the planning stage based on the owner’s requirements prior to construction initiation. It is a task to develop a construction professional service to increase the completeness of the drawing in order to achieve the project goals without significant issues during construction. In addition, identifying a competent construction partner for construction is also an important activity within PCA.

In depth study of design management, the key to PCA, was also initiated for this research. Best practices cases for partnering and integrated project delivery (IPD) were reviewed and the how performance can improve through PCA was discussed.

Case studies and critical success factors (CSFs) on schedule reduction and PCA, the main topic for this research, were analyzed. The Empire State Building (ESB) built in the early 1930s is an example of schedule reduction and was analyzed thoroughly to determine the methods utilized to reduce construction schedule, and its applicability was further discussed. Then, schedule management issues in the Korean construction industry were discussed and method to reduce schedule through PCA was suggested.

PCA evaluation form was developed based on the CSFs of a project to evaluate how well PCA is performed for a specific project and suggested as a tool to assess the PCA performance.

The developed PCA evaluation form was verified based on a pilot test and the relationship between PCA and schedule reduction, schedule reduction and customer satisfaction, customer satisfaction and NPS was analyzed based on 8 years of customer survey data aggregated by H-Company.

Analysis results showed PCA had a distinct causal relationship with schedule reduction, customer satisfaction and NPS. The relationship between PCA and schedule reduction showed that the effect of schedule reduction due to PCA was maximized when PCA was performed early in the project phase during preconstruction. Especially, this research proved that PCA was most effective in schedule reduction for tall and super tall projects. PCA had also an effect on schedule reduction which is a factor of performance satisfaction, as well as reliability, a factor of process satisfaction. After analyzing the effect of PCA on NPS, the longer PCA phase and more manpower utilized for PCA yielded to higher NPS at the end of a project.

When PCA accounted for 30% of the total work period, there was a 45.3% difference in NPS compared to that of projects that did not perform PCA. When manpower mobilized during preconstruction accounted for more than 30%, a difference of 48.3% was shown compared to projects without PCA, proving that PCA has a significant impact on NPS. Such results was possible due to the virtuous cycle where that is verified in this research where a well performed PCA can achieve high completeness of design as well as selection of construction team → construction with high quality and high productivity → project success → customer satisfaction → increased net promoter score (NPS).

The research contribution can be summarized as the following.

(1) The importance of PCA was discussed in various perspectives and case studies, and the possibility of schedule reduction through PCA was established.

(2) The PCA evaluation form was developed based on critical success factors (CSFs) and its feasibility was verified. It was also suggested as a tool to evaluate how well PCA is performed for a project

(3) This research proved that customer satisfaction is possible by performing PCA and achieving qualitative performance and quantitative performance.

Also, by analyzing the NPS data, this research determined that satisfied customer can become a loyal customer.

(4) The theory of customer satisfaction and NPS was systemized in the construction industry which contributes to the customer satisfaction management. This research points out that a repetitive purchase by loyal customers lead to profit. Therefore, the virtuous cycle model is suggested as a new paradigm for the management in construction.

Keywords: customer loyalty, customer satisfaction, design management, Net Promoter Score (NPS), PCA evaluation form, PreConstruction Activities (PCA), schedule reduction,

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Chapter 1. Introduction

1.1 Research Background

Every stakeholder (owner, designer, constructor, etc.) in a construction project wants the project to be successful and therefore puts effort in achieving it (CII, 2009). However, a successful project is not easy to achieve and there have been many cases where the project was not able to meet the planned goals by either exceeding the cost or schedule. Nevertheless, it is possible to increase the chance of success by being aware that the key point to a successful project lies in the early stages of the project.

Preconstruction phase accounts for pre-design, design and procurement phase among the 5 stages of project life cycle (CMAA, 2015). During the preconstruction phase, tasks related to setting the project goal, designing, and procuring are performed in preparation for construction. In particular, PreConstruction Activities (PCA) can be defined as tasks, such as verification of schedule, cost, quality and other various matters, performed in order to achieve the project goals for the success of the project. Based on Figure 1-1 and Figure 1-2, it is well known that PCA have a significant effect on a project which can eventually influence the success of the project.

However, the concept and importance of PCA is not well acknowledged and is underestimated in Korea. Orders for complex and large projects are constantly increasing in the Korean construction market and as a result, the risk factors (cost increase and delay in schedule) are also increasing. Despite the efforts to overcome such risks by having experts participate in the early stage of the project in order to establish a project plan and help with proper and informed decision making, the lack of PCA has led many projects to lose opportunities at the early. This results in “trial and error” during construction due to uncertainty which leads to increase in project cost and delay in the schedule.

The reason for the lack of awareness in the importance of PCA can be summarized as the following: ① design and construction separation due to delivery methods such as design-bid-build (DBB) and lack of awareness and need by the owners team (including CM/PM company and outside consultants) performing PCA; ② burden of initial cost and lack of awareness on the service; ③ common practice of slacking at the early stage of a project and attempting to mend the mistakes later in the project; and ④ the tendency of the owner in transferring all risks to the constructor in order to not be held responsible.

In comparison, the US, the UK and other western countries are very well aware of the importance of preconstruction phase and therefore, puts more effort into PCA when pursuing a project. Since they initiate construction after verification in the preconstruction phase, they are able to increase the certainty of a project and identify issues in advance. As a result, not only are they able to follow the project schedule and cost as planned but also reduce the project schedule.

The characteristics of PreConstruction Activities can be said to be project planning and simulation before construction for successful construction. In other words, PCA are the tasks included in the first half of the project which prepares for the second half of the project, construction. The direction of the construction is clearly driven by PCA and it is responsible in providing management points and rules for construction. If construction can be said to be hardware, design, construction schedule, quality plan, etc., which are PCA can be said to be professional service programs. Project planning activities for PCA include establishing plans and creating competitive design drawings. Value engineering (VE) and constructability review are performed for the project success, which includes quality management, schedule management, and cost management tasks, are performed prior to construction. Identifying a competent construction partner for construction is also an important activity within PCA. Consequently, PCA during preconstruction phase has a profound effect on the project success. Based on Design & Cost Commitment (Figure 1-1), pre-design and design phase is said to influence 90% of the project cost. The cost influence curve (Figure 1-2) portrays how there is a lot of opportunity and influence during the early stage of a project and this drastically decreases over time. In contrast, the cost of change orders sharply increases over time.

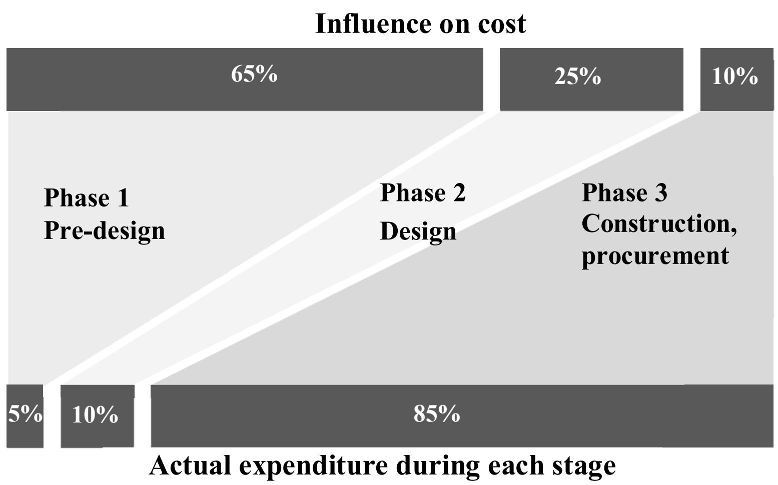


Figure 1-1 Design & Cost Commitment (Langdon & Seah, 2002) (partially edited)

Therefore, it is imperative to understand the importance of preconstruction phase and PCA, the barometer of project success in Korea. Based on the proper knowledge of PCA, it is advantageous to establish a virtuous cycle by performing PCA successfully to enhance the project performance, leading to customer satisfaction. A system to evaluate how well PCA is being performed is also necessary.

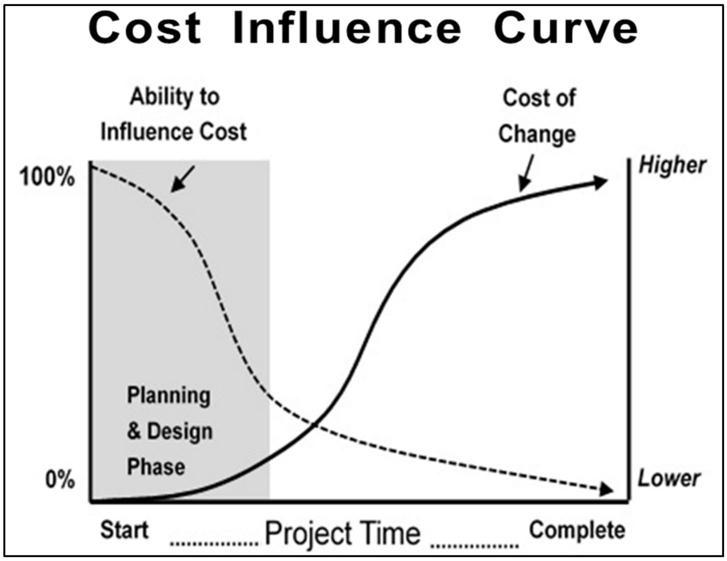


Figure 1-2 Cost Influence Curve (Rocque, 2003) (partially edited)

1.2 Problem Statement

There has been a large quantitative growth in the Korean construction industry (construction market in Korea ranked 14th in Global Construction Outlook, 2016, and 4th in ENR, 2016) in terms of overseas market share. However, qualitative growth has not developed as much as the quantitative growth. Korea is far behind other western countries when comparing the professional service (planning, design, engineering, and project management) of construction. This is causing many issues in a construction project and which results in Korean construction companies to lose its domestic and overseas competitiveness. In Korea, because the separation between design and construction is common and the construction environment is centered on the constructor, there is a limit in being able to further develop the construction professional service. Separation of design and construction makes it more difficult for the constructor to participate during the design phase leading to lack of awareness in PCA. Furthermore, construction professional service, which includes design services, is below the global standard and has contributed to the lack of competitiveness in construction. Design services that lack quality and completeness, have incomplete cost, schedule, quality, and safety plans which should have been established during the preconstruction phase. Hence, numerous design changes occur during construction yielding to cost overruns, lower quality and operational problems. This will eventually create an unsatisfied customer. Therefore, this research attempts to identify and discuss the following issues:

(1) Lack of awareness in the importance of preconstruction and negligence of PCA is observed. Either the Korean construction industry is underestimating the importance of PCA, leading to lack of effort in PCA or not performing PCA effectively. As a result, there is delay in decision making for the project and its numerous design changes, consequent delay in schedule, cost increase, and decreased quality due to the underdeveloped design.

(2) During such process, it becomes difficult for the project stakeholders to communicate, lowering the trust within each other. Once the project is

completed, due to the lack of performance, the satisfaction of the owner also decreases.

(3) There is a lack of assessment method or verification system to determine whether PCA is being performed appropriately. While it is also important to know if PCA is being performed or not, it is important to have a tool such as a procedure or a manual for a competent person or team in order to be able to evaluate each task phase. Measures can be taken for areas that are underperforming and failures can be prevented. However, the Korean construction industry lacks such an assessment and verification system.

1.3 Research Objectives and Scope

1.3.1 Research Objectives

This research attempts to prove that a successful project as a result of systematic PCA can enhance the customer (owner) loyalty index, net promoter score (NPS) by analyzing the PCA key factors and best practices. Especially, this research will utilize real examples to prove that it is possible to largely reduce the project schedule and cost at the early stage of a project with the will and capability of the owner and project participants and implementing the necessary resources. Finally, this research attempts to prove how a project can become successful through successful PCA which can enhance customer satisfaction.

Therefore, through this research (1) a PCA evaluation form is compiled to assess how well PCA is performed based on the critical success factors (CSFs) for project success. (2) Awareness on the importance of PCA is discussed in various viewpoints and the concept of PCA is organized. Then the significant relationship between PCA and schedule reduction is proved. (3) Customers will not only be satisfied of the project success based on PCA but also through process satisfaction, their loyalty will be strengthened and lead to customer satisfaction. (4) Thus, the customer loyalty index called Net Promoter Score (NPS) is enhanced and how PCA can contribute in acquiring loyal customers is proved, completing the virtuous cycle.

1.3.2 Research Scope

The scope of the research is (1) limited to the preconstruction stage which is composed of the three phases (pre-design, design, procurement) of the five phases in construction. Construction or post-construction activities are very extremely limited. Also, among the major activities in PCA (schedule, cost, quality, and safety) this research is focused on schedule. (2) In order to analyze the correlation between PCA and schedule reduction, PCA and customer satisfaction, customer satisfaction and NPS, projects with similar characteristics, such as office buildings and mixed-use buildings, were utilized. To prove the hypothesis that PCA has a profound relationship with NPS, this research will analyze the customer survey data accumulated for the past 8 years by H-company, a leading CM company in Korea. Also, the data will be based on projects where the CM company had responsibility in the owner's point of view.

Although this research scope is focused on buildings, the PCA evaluation form can be modified to meet the needs of civil, plant, or any other projects as it is a tool that can be utilized for any type of project. Furthermore, the customer satisfaction research and NPS utilized for this research can be used for any other construction-related companies. This research is focused on the owner's point of view and is limited in terms of constructor, designer or other supplier's point of view.

Through this research, the importance of PCA will be acknowledged, and the relationship of how systematic PCA helps decrease construction schedule which will result in enhanced customer satisfaction as well as NPS will be proved. The goal of this research is to establish and prove the theoretical concept of the PCA-NPS cycle. The secondary goal of this research is for the construction companies to acquire repeat orders from loyal customers who may help the company acquire new customers through their recommendations.

1.4 Research Structure

This research follows three logical processes in order to solve the research problem which can be summarized as the following: (1) literature review on PCA and schedule reduction through PCA, (2) developing a PCA evaluation form to evaluate PCA, and (3) verifying the relationship between PCA and NPS.

First process of literature review on PCA includes identifying the issue in the lack of awareness of PCA. Based on the literature review, the concept and categorization of PCA is recapitulated. Then, the core of PCA, which is design management, is reviewed. After, literature review on schedule, customer satisfaction, and NPS that are related to PCA, is carried out. Limitations of previous studies and method to overcome such limitations are discussed. PCA and schedule reduction cases are studied in order to establish the relationship between PCA and schedule reduction. Then the Empire State Building (ESB) example is analyzed. Afterwards, the issue with schedule management in Korean projects is reviewed, and methodology of reducing schedule through PCA is suggested.

Second process, developing a PCA evaluation form to evaluate PCA, provides a tool to assess how well PCA is being performed after the first process of enhancing the awareness of PCA. The tool is developed based on the CSFs, and the feasibility of the PCA evaluation form is verified by consulting experts, and by conducting a pilot test on projects that have performed PCA.

Third process, verifying the relationship between PCA and NPS, expands the PCA pilot test carried out in the second process to verify the PCA performance based on actual data. This research attempts to verify that PCA is capable of supplementing the schedule management issues with Korean construction projects leading to satisfied customer and acquiring loyal customers. As such, PCA performance is divided into quantitative and qualitative performance for verification. Quantitative performance verifies the end result of how much schedule reduction affected the performance. Qualitative performance observes how well the customer’s needs have been met throughout the project. This research method and process can be analyzed as shown in Figure 1-3.

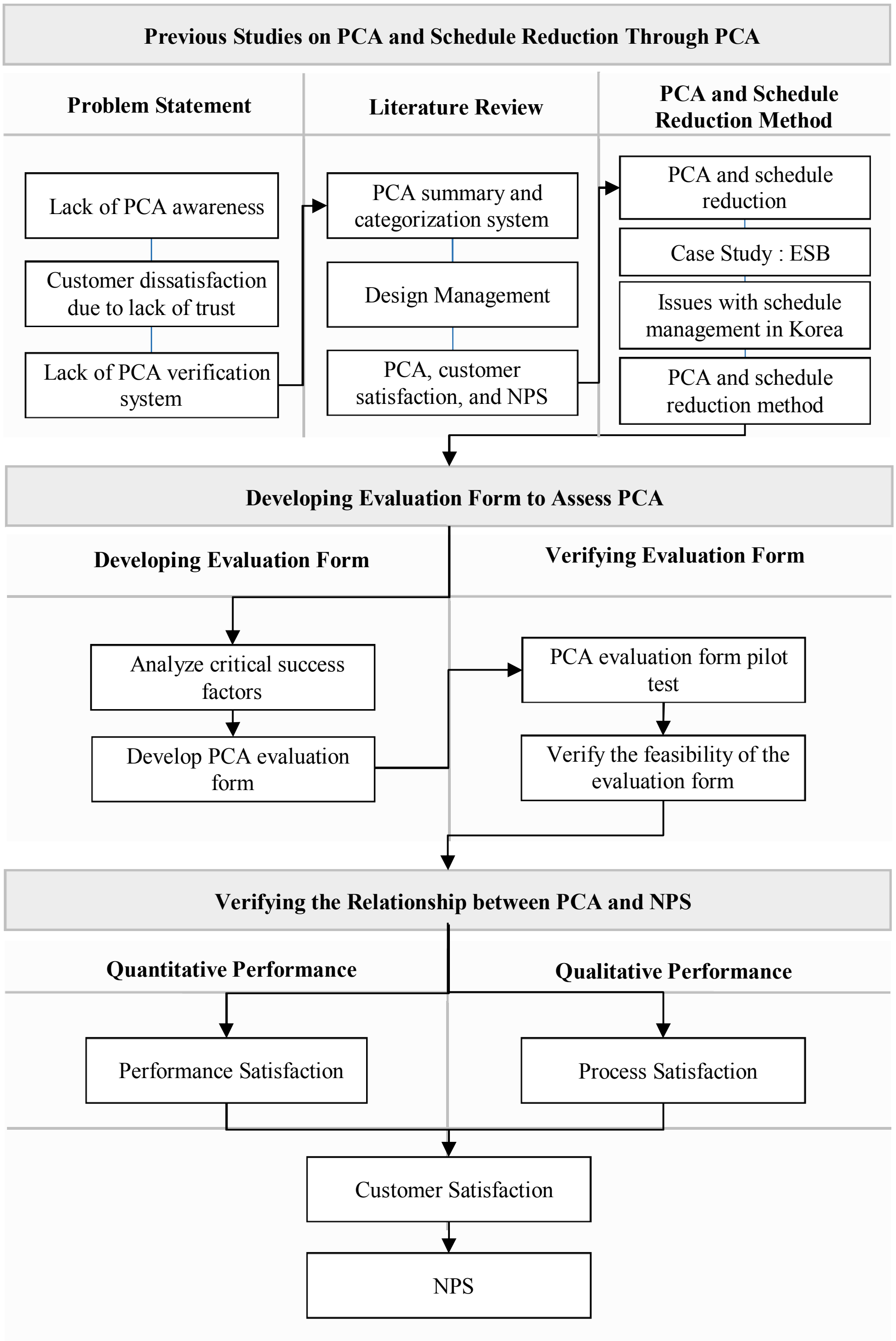


Figure 1-3 Research Process

Chapter 2. Literature Review on PreConstruction Activities (PCA) and Customer Satisfaction, and Net Promoter Score (NPS)

PreConstruction Activity (PCA) is composed of activities related to pre-design (concept), design, and procurement phase, which is well known to have a significant impact on the success of a construction project. The concept of PCA is summarized in this chapter. Preliminary study is performed to identify a relationship between PCA and schedule reduction, PCA and customer satisfaction, and customer satisfaction and NPS. The conclusion of Chapter 2 includes the limitations of previous studies and methods to overcome such limitations, including a conclusion for the chapter.

2.1 Summary and Classification of PCA

This section discusses the concept of PCA in details. The classification by Project Management Institute (PMI) and Construction Management Association of America (CMAA) are discussed in details.

2.1.1 Concept and Definition of PCA

(1) PCA Concept and Performing Organization

Concept of preconstruction is not distinctively defined either by both PMI and CMAA. Preconstruction phase is not classified separately from the construction phase, but rather the project is defined in 5 phases with specific activities. Therefore, the concept of PCA is clearly defined to distinguish the difference between construction activities and PreConstruction Activities.

PCA involves activities to prepare for construction and PCA may differ according to the case due to the contract type or owners. However, PCA can be categorized to three types. First type consists of the 3 of the 5 construction phases prior to construction, pre-design (concept), design, and procurement phases, which is called the preconstruction phase. As such, PCA are the activities performed during the preconstruction phase. The owner or the representative of the owner, CM/PM, leads PCA. Second type involves the construction company performing design review, VE, cost, and schedule review and so forth prior to construction in order to select a subcontractor for construction. Third type is the integrated project delivery (IPD) method which is the early involvement of constructors to perform preconstruction services for a construction project. IPD is one of the project delivery systems in which a general contractor (GC) participates early in the project by providing preconstruction services (PCS) through contracts such as CM-at-Risk. The constructor can also be called a GC/CM. This research, however, focuses more on the concept of PCA which defines activities before construction rather than PCS in terms of a delivery system. As much as preconstruction phase is essential for project success, there is no doubt that PCA, an activity within the preconstruction phase, has an absolute impact on project success. According to Reginato and Alves (2012), not only the owner benefits from preconstruction but also it reduces the risks for all parties involved. As shown in the cost influence curve (Figure 1-2), the early phases (pre-design and design) of a project are the most important phase for project success.

(2) Definition of PCA

Based on the concept of PCA, it can be defined as the following:

"*Among the 5 phases for construction, PCA involves the phases prior to construction which are pre-design, design and procurement phase. PCA represents the activities that are performed to prepare for construction. Especially, activities including cost, schedule, quality, and other project objectives established during the concept (pre-design) phase are constantly verified and simulated in order to carry out the project according to the plan.*" The goal of such activities can be said to be for the project success and PCA is well known to have a significant influence on the project success.

First phase of PCA, the concept phase, includes establishing the cost, schedule and other major project goals including the owner's requirements. Initial goals must be viable as much as challenging. In order to do so, the project execution plan must be developed based on strategies to achieve the project goal and project execution philosophy. There must also be a competent organization and a project team that can develop a tool and establish a system which will guide them to project success. According to Project Management Book of Knowledge (PMBOK, 2015), this stage is defined as developing the project charter, which is considered as the most important process in implementing project integration management, and the project charter is to be the project bible.

The second phase is the design phase where the design drawings are developed to be complete and competitive. The key to PCA is design management and all critical decision making is performed during this stage. As shown in Figure 1-1, once this stage is completed, the influence of the decisions will have accounted for about 90% of the cost. Munns and Bjeirmi (1996) emphasizes that it is critical to make decisions early in the project for an overall success of the project. Most decision making on other project factors including schedule and quality are also performed during this phase and included in the design drawings. During the second phase, cost management, schedule management, quality management and other project management activities are performed in line with the drawing process inclusive of the continuous value engineering (VE) and constructability.

(3) FEP (Front End Planning), PPP (Pre-Project Planning) and PCA

Both Front End Planning (FEP) and Pre-Project Planning (PPP) were introduced and further developed by the CII (Construction Industry Institute). The definition of FEP and PPP, which is conceptually similar to PCA, is studied and its difference with PCA is stated.

Faniran (2000), defined front end Planning (FEP) as a stage where crucial decisions on (1) project feasibility and (2) strategies to execute the project are made.

Gibson et al (2006) defined pre-project planning (PPP) as a process that involves all tasks from early project stage to detailed design. He is also viewing the concept of PPP as similar to FEB.

The PPP process suggested by Gibson is similar to that of the project charter by PMI. It is also similar to the owner’s requirement and design requirement during the pre-design (concept) stage suggested by CMAA. Both FEP and PPP require the establishment of the project direction as well as the project goals and objectives in order to draft the program to execute the project, which requires the owner's decision in order to continue to the execution stage.

Gibson categorized Pre-Project Planning (PPP) into 4 stages as the following (Figure 2-1): (1) organize for pre-project planning (2) select project alternative(s) (3) develop a project definition package (4) decide whether to proceed with detailed design of the project.

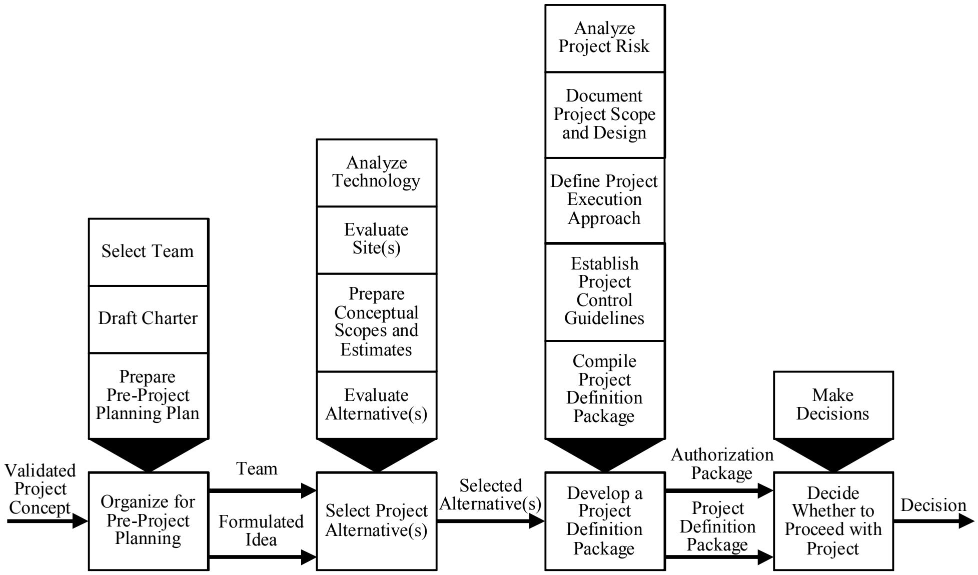


Figure 2-1 Pre-Project Planning Process (Gibson 2006)

2.1.2 Owner-centric PCA and Contractor-centric PCA (PCS)

Owner centered PCA and contractor-centered PCS can differ depending on how the stakeholder relationship is and when it was implemented. The following section will discuss the above mentioned topic.

First, the owner-centered PCA and contractor-centered PCS can differ depending on when it was implemented. Owner-centered PCA is executed during the project inception phase or concept phase, through the owner's project management (PM) organization or other outside PM/CM organization. The owner's organization or representative of the owner will select a designer through the concept phase, or before the design phase, and carry out the design and procurement related tasks.

Contrarily, the contractor-centered PCS is generally involved early in the project after the designer is selected and when the project is in the schematic design phase to perform PCS activities. Due to the difference in when it is implemented, PCS does not include setting up the project, establishing goals or drafting design requirements.

Second concerns the stakeholders' relationship. For contractor-centered PCS, the constructor takes responsibility during the construction for cost and schedule, and therefore, is a party of interest. This is similar to the organization in CM-at-risk projects who are considered to be the constructor. For agency CM, a CM company exists to represent the owner's benefit. On the other hand, it becomes debatable whether the organization for CM-at-risk is capable of overcoming the risks and its own interests to represent the owner's benefit during PreConstruction Activities. Therefore, contractors who perform PCS have the tendency to acquire larger fees based on cost estimation and schedule to accommodate the risks prior to establishing a guaranteed maximum price (GMP). This can be summarized as shown in Table 2-1. Generally, when a contractor-centered PCS is performed, a small PM team from the owner will exist who will determine the final decisions and supervise the contractors.

The most common contracting method for PCS is CM-at-risk or CM/GC, which is widely used by the US department of transportation. According to Schierholz

(2012) CM/GC delivery method is chosen for PCS. Even for design-bid-build method, it is possible for the constructor to provide PCS for the owner during the design phase, and PCS is usually performed by the constructor in order to prepare for construction.

Table 2-1 Comparison between Owner-centered PCA,
and Contractor-centered PCS during IPD[1]

Organization / Type	Owner-centered PCA	Contractor-centered PCA(PCS)
Implementation time	Early stages of a project	Schematic design when the conceptual design is complete[2]
Cost goal	Tight budget	Broad considering GMP
Schedule goal	Tight schedule	Broad schedule within the risk
VE	Streamline as much as possible	Passive considering GMP
Constructability	Possibility of insufficient review	Detailed review
Quality	General level	Review for feasible methods
Design	Focused on aesthetic-centered features	Constructability review Improve construction details
Risk	Challenging goals	Reduce risks

2.1.3 Literature Review on the Classification of PCA

CMAA defined preconstruction in the Construction Management Standards of Practice (CMSP) (CMAA, 2015) to include pre-design phase, design phase, and procurement phase, and included PreConstruction Activities for each phase. In other words, CMAA categorized based on the activities. Similarly, PMI's Project Management Book of Knowledge (PMBOK 5th Edition, 2013) does categorize according to activities but suggests the activities separately making it easier to understand which activities are needed for each phase. Identifying the difference in

[1] IPD: integrated project delivery; explained in details in Chapter 2.2.5
[2] In the US, the recent trend on when the contractor for CM-at-Risk are being hired is about the same time as when the designer is contracted.

categories for both organizations may not be reasonable as the terminology and the categorization itself differs greatly. However, if rearranging the categorization system by CMAA to match that of PMI's, it will be similar to Table 2-2. In this chart, activity lists have been reorganized according to pre-design, design, and procurement phase.

The five construction process or phases defined by PMI is identical to that of CMAA. However, PMI separates the construction process as initiating process, planning process, executing process, monitoring & controlling process, and closing process, which is a different perspective from CMAA. What is unique is that PMI included procurement in the executing process unlike CMSP, which is included in the preconstruction phase. Also, although the activities are similar to CMAA, the project management process group, which manages the five processes, takes the project management process and organizes it so that the activities can be viewed according to the process timeline, which makes it easier to understand the interrelationship between the activities (Table 2-3).

Also, PMI utilizes a flow chart to explain the relationship of the five process which helps understand the causal relationship among the processes. Furthermore, the interaction between the process and peak time can be seen in Figure 2-2. Meanwhile, Chapter 2, project management, in CMSP handles project management separately for each project phase and supplements the activities in general. Another characteristic of PMBOK are the various charts, pictures, flow sheet, diagrams, etc., that make it possible to easily understand the PM knowledge system, whereas CMSP has very little visual aids.

Table 2-2 Activity List based on Preconstruction Phase (Construction Management Standard of Practice, Edited)

Pre-Design Phase

Project Management
- Project Organization
- Project Management Plan (PMP)
- Project Procedures Manual
- Pre-Design Project Conference
- Management Information System

Cost Management
- Preliminary Cost Investigation
- Pre-Design Phase
- Project and Construction Budget(s)
- Cost Analysis

Time Management
- Master Schedule
- Milestone Schedule
- Contract Development
- Float

Quality Management
- Goal
- Clarifying Owner's Objectives
- Scope of Work
- Project Organization
- Quality Management Plan (QMP)

Contract Administration
- Goals
- Planning
- Design Consultant Contracts
- Communication Procedures

Safety Management
- Owner Commitment
- Initial Scope of Services for CM Providing an Overall Jobsite Safety Program
- Project Organization
- Staffing Considerations

Sustainability
- Establishing Project Sustainability Goals
- Contract Development
- Project Management Plan (PMP)
- Project Commissioning Plan
- Pre-Design Project Conference

Building Information Modeling
- Establishing BIM Goals & Objectives
- Selection of the Design Team
- Contract Development
- Project Management Plan (PMP)
- Model Development by the CM
- BIM and Project Delivery Systems

Design Phase

Project Management
- Design Document Review
- Document Distribution
- Contract Agreements
- General and Supplementary General Conditions
- Public Relations
- Project Funding
- Meetings
- Cost Management
- Time Management
- Sustainability Compliance
- On-Going Consulting Activities

Cost Management
- Estimates
- Cost Verification Stages
- Schematic Design Estimate
- Preliminary Design Estimate
- In Progress and Final Design Document Estimates
- Value Analysis/Value Engineering Studies
- Cost Monitoring and Reporting

Time Management
- Maintaining the Master Schedule
- Design Schedule
- Monitoring the Design Phase
- Pre-Bid Construction Schedule
- Schedule Reports

Quality Management
- Goal
- Document Control
- Review of Design Submittals
- Design Criteria Changes
- Quality Control
- Quality Assurance Plan
- Building Information Modeling (BIM).
- Constructability Reviews
- Sustainability
- Value Engineering
- Risk Management
- Establishment of Construction Duration
- Construction Testing Requirements
- Quality Management Specifications
- Implementation of QC/QA Requirements During Construction
- Public Relations/User Review
- Project Funding
- Project Review Meetings
- Reports

Contract Administration
- Goal
- Design Phase Progress
- Design Review Meetings
- Construction and Permanent Easements
- Utility Agreements
- Schedule Maintenance Report
- Project Cost Report

Sustainability
- Procurement Phase
- Meetings

Building Information Modeling
- Compliance with BIM Standards
- Design Document Review
- Document Control
- Contracts/Agreements
- Public Relations, Community Outreach, and Buy-In
- Cost Control

Procurement Phase

Project Management
- Bidding and Contracting Process
- Meetings

Cost Management
- Estimates for Addenda
- Bid Analysis and Negotiation

Time Management
- Contractor's Construction Schedule
- Addenda
- Schedule Reports

Quality Management
- Goal
- Procurement Planning
- Advertisement and Solicitation of Bids
- Select Bidders List
- Instructions to Bidders
- Pre-Bid Conference
- Proposal Document Protocol and Bid Opening
- Pre-Award Conference
- Contract Award

Contract Administration
- Goal
- Bidder Prequalification
- Development of Bidders List
- Bidders Interest Campaign
- Notices and Advertisements
- Delivery of Bid Documents
- Information to Bidders
- Addenda
- Pre-Bid Conferences
- Bid Openings and Evaluation.
- Post Bid Interview
- Construction Contracts
- Schedule Maintenance Report
- Project Cost Report
- Cash Flow Reports

Safety Management
- Pre-Bid Conference
- Emergency Response Coordination

Building Information Modeling
- Influence of Delivery Method
- Bidding and Contracting Process

Table 2-3 Project Management Process Groups and Knowledge Areas Map (PMBOK 5th)

Knowledge Areas	Project Management Process Groups				
	Initiating	Planning	Executing	Monitoring & Controlling	Closing
Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.8 Close Project or Phase
Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
Project Communication Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Another difference between PMBOK and CMSP is that developing a project charter is one of the activities in the pre-design phase for CMSP. Project charter includes contents concerning project requirement, project description, project budget, and schedule, along with project objective and success criteria. Also, procurement phase does not exist as it is included in the planning and execution process, and construction phase is separated into executing process, and monitoring & controlling process. PMI takes human resources management, communication management, stakeholder management, and scope management as a major activity unlike CMAA. On the other hand CMSP includes sustainability management and building information modeling (BIM) that is not handled in PMBOK.

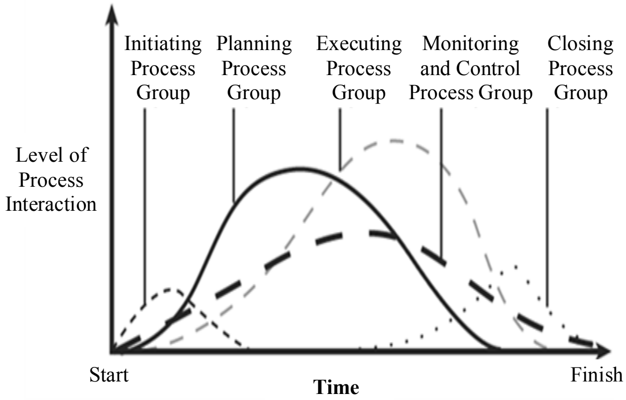


Figure 2-2 Project Management Process Interactions (PMBOK 5th)

The difference in the two organization's categorization falls in the difference of background and development history. PMI is focused on industry such as plant and manufacturing rather than buildings, whereas CMAA is centered on buildings and civil, which is why it is possible to assume that the list is focus on different types of customers. PMI needs to include building and civil projects management. Especially during preconstruction, PMI's management points such as resource, communication, interests, scope, and risk, need to be reinforced. Considering PMI, established in 1969, has a longer history than CMAA, established in 1982, it is possible to assume that PMI would have more members from various industry and field, and therefore have a more systematic and in depth knowledge on project management. Nevertheless, it is necessary for Korea to benchmark the body of knowledge for project management by both advanced organizations.

Furthermore, previous studies were focused on activities such as cost, schedule, quality, etc. However, there were no systematic research concerning the importance of preconstruction phase (PCP) and PreConstruction Activities (PCA), and there were very limited research on PCA overall. Organizations for CM/PM, such as PMI or CMAA, do not even use the concept or terminology such as PCP or PCA. On the other hand, PCP, PCA, or PCS (preconstruction service) is utilized often in the industry.

2.2 PCA and Design Management (DM)

Project managers, including the owner, devote their work for a successful project but there are many cases in which they fail. There are many reasons that may cause a project to fail but majority of the failures are due to various design issues (CII, 2009).

As such, design has a large impact on the success and failure of a project. Therefore, design management, which enhances the completeness and competitiveness of the drawings, is a major activity in PCA that contributes in project success. This section will discuss the concept of design management, key methodology, and relationship between design management and schedule reduction.

2.2.1 Design Management Concept

Foreign CM professionals have stated that design management (DM) contributes more than 80% in construction management (CM)[3]. DM is similar but different from design review. Design review is the act of reviewing the design. It may review

[3] Not a statistical figure that has solid proof but a number derived based on a number of expert's experience and knowledge

the aesthetic of the design and its function but mostly it functions to identify and evaluate the discrepancy of the design. Identifying the issues with the drawing, detecting clash and coordinating structure, finishing, and MEP, and identifying criteria that can be improved to increase the quality of the design are its major task.

Meanwhile, DM is project management through the design process. The scope of DM includes design review as well as cost management, schedule management, quality management, safety management, constructability review, value engineering, project management, construction administration, etc. In other words, cost, schedule and other management points in a project are reviewed with the development of the design and applied to the design in order to achieve the project goal and owner's requirement. Therefore, design management task becomes the core in PCA and has a significant role in project success as shown in Figure 2-3.

In Korea, the concept of design review is well known but design management, which copes with major design decisions for the project, is not. This is similar to how PCA is not commonly known.

For example, observing the relationship between cost management and DM for the KLCC Petronas project, the designs were controlled constantly in order to match the cost instead of completing the design and checking the cost. However, if the design drawings happened to exceed 30% of the construction cost during the concept design phase, measures to decrease the 30% instead of proceeding to the schematic phase through either VE or design change is pursued. In other words, design and cost are synchronized and managed simultaneously. The flow sheet for the KLCC project cost management procedure is shown in Figure 2-4.

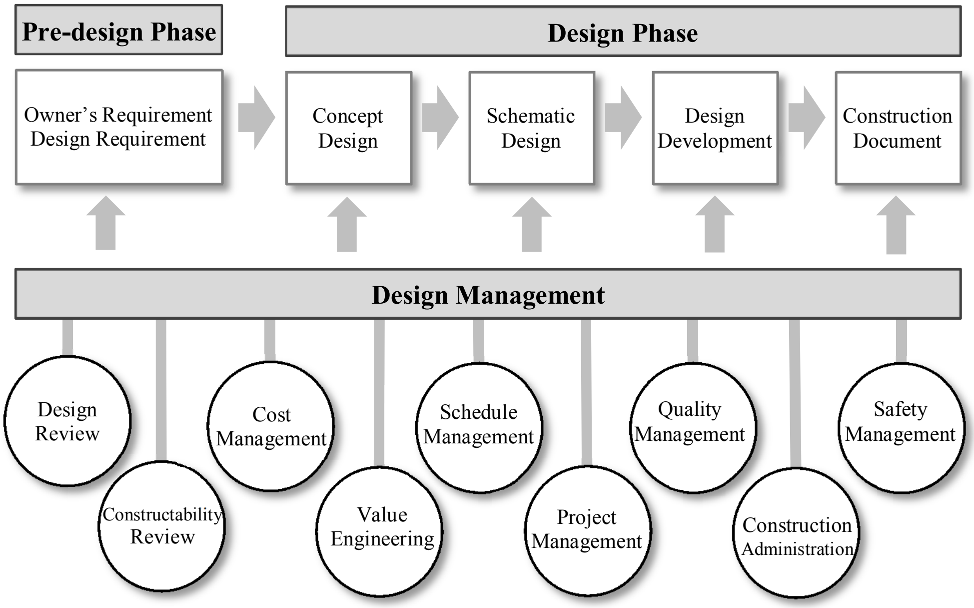


Figure 2-3 Design Management Concept

There is also a similar method in performing more than cost management during the design phase by utilizing target value design which is commonly used in integrated project design (IPD). Before the design, a core team speculates the building system and other many design factors to verify the cost model which actively assists in developing the design. Hence, not only does the DM team but also those who have knowledge on construction and cost have to participate in order to estimate the cost without any designs.

The purpose and advantage of design management is to simulate and review the cost, quality, methods and other design factors during the design phase, and make decisions on time for the architect to continue with the design tasks effectively (Figure 2-3). As a result, construction may begin sooner than planned and minimize design changes during the construction phase.

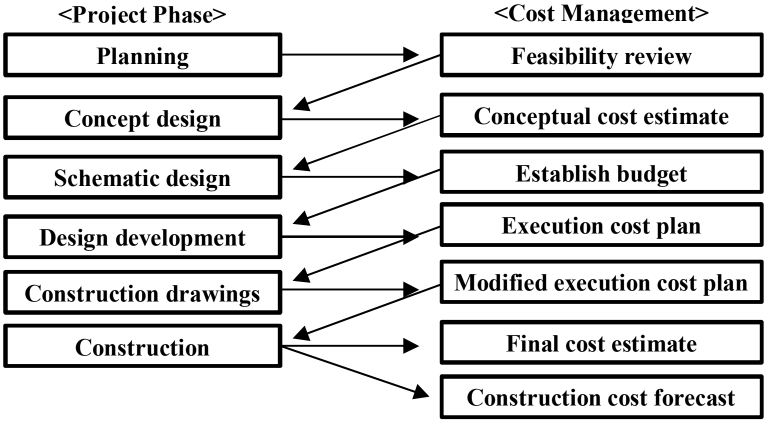


Figure 2-4 KLCC Cost Management Flow Diagram (HanmiGlobal, 2006)

2.2.2 Design Phase and Design Management

The terminology or concept of design stage, which is globally understood, may differ for each country. According to the American Institute of Architects (AIA), there are four stages in the global standard (Figure 2-5): concept design; schematic design; design development (DD, working design); and construction document. Meanwhile, there are three stages (concept/schematic design; basic design; and working design) that are commonly used in Korea which does not align with the global standard.

In foreign countries, when designing or performing project management for a major project, the design stage is further subdivided (e.g. concept 50%, 100%; schematic design 25%, 50%, 75%, 100%; design development 25%, 50%; 75%, 100%; and construction documents 50%, 100%). Based on the review cost and schedule related decision making for each subdivided phase, it is further examined with the owner's requirements. The design only proceeds to the next step once it is approved by the owner.

In Korea, however, cost, construction method, schedule, etc., are not reviewed thoroughly in a project design which leads to rework and errors during construction. This is due to the fact that design management has not been well performed.

CMAA defines the activities that must be carried out during the design phase as project management, cost management, time management, quality management, contract administration, sustainability, and building information modeling, and each activity include specific tasks (Table 2-2).

Another critical criterion during the design phase is to have a design goal for each stage, which is also unclear in Korea. For example, when there is a fast track project, overall design must be completed by the schematic stage. During the design development stage, design should follow the order of the construction such that design of the basement structure should be completed first then the ground floor structure. Then basement finishing and other construction items in the order of construction. When the schematic design is complete, the core where the elevator shaft enters must be fixed and there should be no changes in the dimensions in the plans. As mentioned before, the steps mentioned above are omitted in Korea and there is a misconception that fast track to be initiating construction without schematic design.

If IPD is utilized during design as seen in Figure 2-5 and Figure 2-6, it is possible to perform detailed design in advance as not only the constructor but also specialty contractors are involved to provide both building system and construction details.

This can result to reduce the construction schedule drastically. Recently, BIM tools have enabled constructors to accurately communicate and perform cost, schedule and constructability review more effectively.

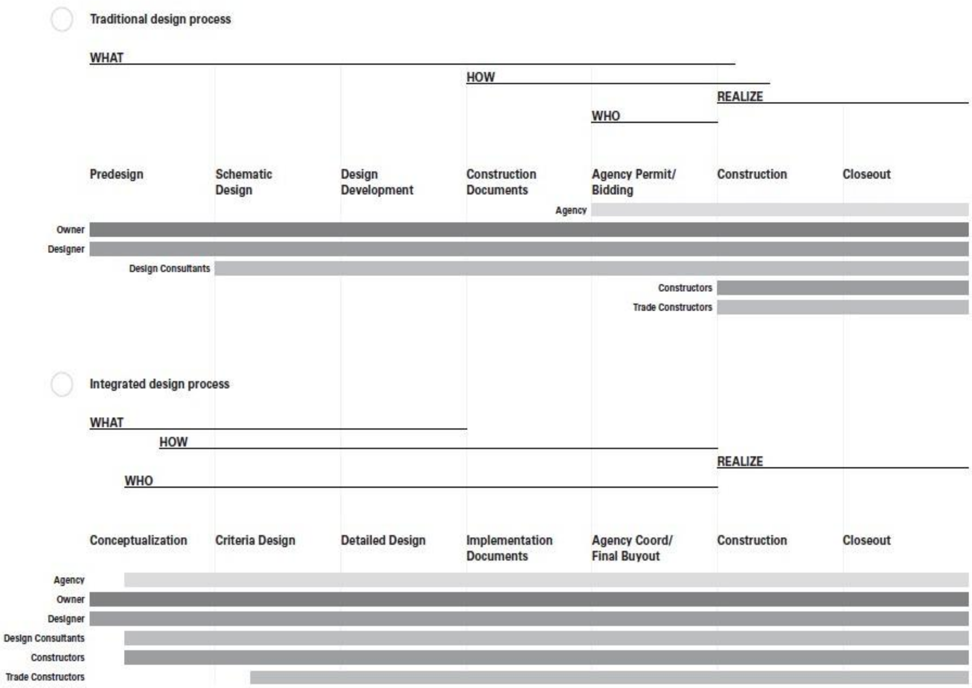


Figure 2-5 Traditional Design Process VS Integrated Design Process (AIA, 2007)

2.2.3 PCA and Best Practice Methods

Ancient architecture usually had a master builder to manage the design and construction. Hence, the master builder had great knowledge in both design and construction. During the renaissance era, Michelangelo, and Kim Dae Sung, who built the Bulguksa4 Temple in Korea, were the master builders of their times.

4 Bulguksa is an iconic ancient monument in Korea that was constructed by Kim Dae Sung during the unified Silla era about 1250 years ago. It is currently registered as a cultural heritage of humanity by UNESCO.

During this period, most buildings were built centered on the master builder. Even 100 years ago, a single company had the responsibility as a master builder since the company performed all the required tasks.

Today's construction performance needs to evolve to become more intelligent and smart and it has become essential for specialty contractors to participate in the construction project to cope with its complexity. However, the construction activities have been subdivided into too many parts which Thomsen (2009) considers it as to be specialized yet fragmented industry. Therefore, it is necessary to put effort in integrating all the fragments at the beginning of the project. The UK's Partnering method and the US's IPD method, which are similar in nature, are the best practices in integrating the fragmented activities. If the design management, the key in PCA, adopts a contractual method such as partnering or IPD, it will be possible to perform a much more effective PCA.

2.2.4 Partnering and PCA

Partnering method was one of the major movements in the UK's Rethinking Construction. Partnering is more than just a contractual boundary amongst the owner, designer, constructor, and other project related organizations but rather a management method of encouraging and enhancing trust and collaboration through teamwork. Partnering focuses on three criteria which are mutual objectives, problem resolution, and continuous improvement (Kim and Kim, 2002). Enhancing end-client satisfaction (Black et. al., 2000) and decreasing claims by 50% (Thomsen, 2009) are only a few of the many advantages of partnering. According to Kim and

Kim (2002), through partnering it is possible to (1) minimize opportunity cost and inefficiency, (2) decrease disputes and lawsuits, (3) increase productivity, (4) technology innovation during design stage, (5) decrease procurement time, and (6) aggregate knowledge among the partnering participants.

In order to maximize the effect of partnering, it is necessary to trust, communicate, commit, clearly understand roles, and have consistent and flexible attitudes (Black et al., 2000).

Partnering can be separated into a project-specific partnering and strategic partnering based on long-term relationship (Kim, 2002). In the UK, Rethinking Construction derived a Principal Supply Chain Member (PSCM) for design and construction related suppliers in order to establish a framework agreement that must be valid for a minimum of 5 years in order to maintain a long-term trading partnership (Kim, 2006). The organization that initiated such innovative procurement was the Natural Health Service (NHS) in the UK. This innovative program was called the "ProCare 21" and explains the partnering program as the following:

"The amount of benefit the owner can receive through repeated medical facility projects with the few well-selected leading companies is grand. Partner company can have a better understanding of the owner's needs and gain experience, and the owner can learn about the best practices that will eventually enhance the construction industry" (Kim, 2006).

It is necessary to share the various best practices, similar to that of the US or UK's partnering method, if PCA (or PCS) is to succeed. Since PCA is about simulating the construction prior to construction, collaboration of the project stakeholders is necessary and important to achieve the project goals. Also, partnering is not limited to preconstruction but also includes the construction under the same philosophy and goals. If the concept of partnering is embedding in PCA, PCA will be more performance and collaboration based which could further help achieve project goal and project success.

2.2.5 Integrated Project Delivery (IPD) and PCA

Integrated Project Delivery (IPD) is a concept mostly used in the US where many tools and techniques, and best practices are shared. There are many similar aspects with the partnering concept used in the UK.

Similar to how the UK's Principal Supply Chain Member (PSCM) participates at the early stage of a project, the owner, architect engineer, construction manager, and other key consultants or contractors participate at the early stage of a project for IPD (Thomsen, 2009).

Modern construction projects involve a various stakeholders that decrease the efficiency due to low collaboration between design and construction. Low competitiveness of the design and inadequate quality of the drawings have caused a number of design changes including cost increase and schedule delay, which was the background of how IPD came into life. IPD became more prevalent since the 1990s in order to innovatively achieve the owner's goal by improving the issues that were embedded in the previous project delivery methods. According to the CMAA Owner's Survey conducted in 2005, 92% of the projects owners responded that the design drawings were not sufficient for construction. Also, in the CMAA Industry Report 2007, 30% of projects are not within schedule or budget. Furthermore, the Economist Magazine (2002) stated that 37% of materials used by the construction industry became waste. Such statements emphasize the fact that today's delivery method includes various issues that require drastic improvement.

AIA (2007) defines IPD as the owner, designer, constructor, and consultant in forming a team to perform a project under a single process where risk and reward are shared, and the success of the project is dependent on the stakeholders. Hence, ① IPD is a contract method of ② multi-party contract that share both risk and reward (incentive) ③ which is linked to the project success. Therefore, having all the stakeholders involved early in the project as a single entity will enhance teamwork to achieve the owner's goal and lead to project success. The key to IPD is the integration of design and construction, and through IPD, the project cost, schedule, quality goals are systematically managed from the very initial stage. Also, since the owner, including designer and constructor participate in IPD, it will be possible for a speedier decision making on the design and resulting in the completion of the drawings faster, hence, contributing to schedule reduction (Figure 2-6).

Unlike the conventional design work flow, IPD involves specialized contractors early in the project to make decisions on the design, which is the reason for reduced design flow as shown in Figure 2-6.

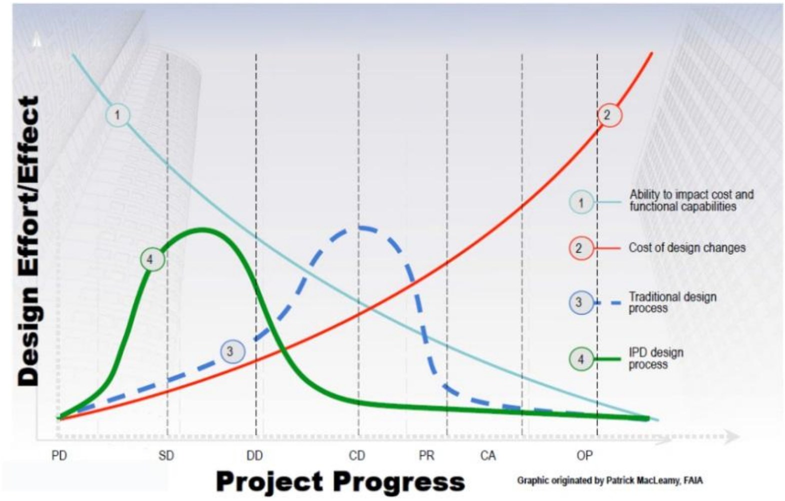


Figure 2-6. Project Progress MacLeamy Curve (Darrington 2014)

There are many benefits for the owner, designer and contractor in utilizing IPD. Especially for the designer, the design quality can be improved significantly reducing and preventing rework on the design. For the constructor, as it is possible to review the construction method, cost, schedule etc., from the early design phase, it is possible to significantly reduce the project risk. The owner benefits from achieving the project goals through IPD, which results in customer satisfaction.

It is common for BIM, PMIS (project management information system) or similar tools to be used in IPD. Lean, target value design, design assist, and other methods are also utilized. A key method in IPD is the lean method which eliminates waste, increases efficiency, adds value and smoothens the work flow (Thomsen, 2009).

IPD is a multi-party contract that shares both the risks and reward in order to achieve the owner’s goal by becoming a single team throughout the project life cycle. Preconstruction phase is a critical period in IPD to create value, and for the success of PCA, PCA needs to be integrated with a project delivery system that is similar to IPD where stakeholders are forced to collaborate. Also, it is necessary for lean, target value design, etc. that has been developed and tested in IPD to be integrated with PCA and information tools such as BIM and PMIS, need to be implemented as well.

2.3 PCA and Customer Satisfaction

The correlation between PCA and customer satisfaction is discussed in this section. First, the types of customers in the construction industry is discussed and followed by the concept of customer satisfaction, and how it is formed. As mentioned before, PCA is an activity to develop the professional service (including design drawings, etc.) in order to create a competitive project and perform appropriate construction, and a process in selecting the suppliers for the constructor. Therefore, PCA has a profound relationship with the customer's needs and requirements, and considering the task is performed for a long duration, customer's satisfaction with the performance is also closely related.

2.3.1 Types of Customers

There are three types of customers in a construction project. According to Ireland (1992), first type of customers is owners or buyers who purchase products or services; second type is the sponsor or investor who directly or indirectly invests in a project; and third customers are those who use the product or the service. Based on the characteristic of a construction project, most facilities are for the users, and due to the difference of interest between the owner and the sponsor, there are various needs in terms of customer satisfaction. As such, the customer can be defined in a very broad manner, but this chapter will focus on the owner as a customer.

2.3.2 Customer Satisfaction in Construction

There are many theories for customer satisfaction, and expectation disconfirmation paradigm, comparison level theory, equality theory, and value-percept disparity theory are few of the major theories. In expectation disconfirmation paradigm, customer satisfaction is described as an equation between expectation and disconfirmation. If a customer experiences a product or service and believes the performance to have exceeded the expectation, there is a positive disconfirmation, and if the performance does not meet the expectation, there is a negative disconfirmation (Oliver 1980; Oliver and DeSarbo 1988; Jeong 2011). Hence, customer satisfaction has a positive disconfirmation correlation with both expectation and actual experience. Othman (2015) defined customer satisfaction to be based on the perceived company image, customer expectation, perceived quality, and perceived value of the cost. Kärnä (2004) defined customer satisfaction in construction project by comparing ① the building quality and project goal; ② perceived quality of the construction process and actual experience; and ③ customer expectation and experience (Figure 2-7).

Since it is difficult in the construction industry to compare a product with another product, and there is no standardized method to compare, the subjective experience of the client becomes more important and essential. Jones and Sasser (1995) stated that the key to securing customer loyalty is to achieve complete customer satisfaction, which in turn will lead to long-term financial performance; hence a key to management.

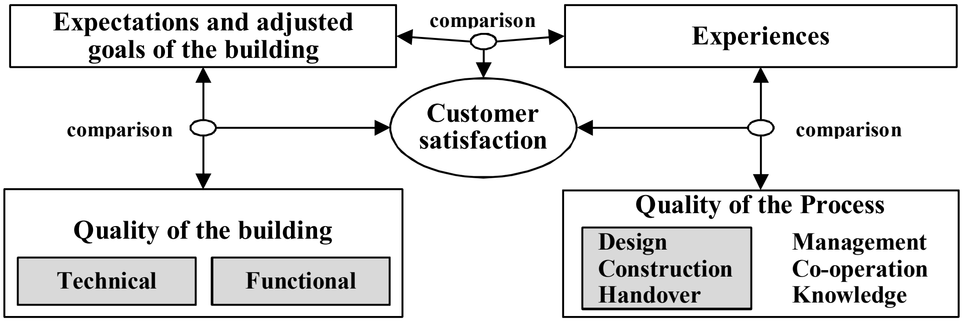


Figure 2-7 Interrelationship between Customer Satisfaction and Quality at Project Level (Kärnä, 2004)

2.3.3 Project Performance and Customer Satisfaction

As mentioned before, customer satisfaction is possible when the performance exceeds the customer's expectation. Customer satisfaction is the most important priority and criteria in determining whether the project was successful (Baccarini, 1999). He believed customer satisfaction was the first and foremost important factor for a successful project.

Project performance can be divided into management success, which involves budget management, schedule management, quality management, etc., and product success. Both successes do not necessarily match one another. If a project was completed within the budget does not necessary mean that the customer was satisfied. Also, a project that had exceeded the budget does not equal to a failed project. For example, the Sydney Opera House project exceeded the project budget by 10 times and project schedule was delayed for 6 years. The buyer may consider it to be a failed project but because of its significant design, it became the best landmark once it was completed and the public users were extremely satisfied with the project (Kim, 2014).

On the contrarily, Empire State Building (ESB) project was a successful project in terms of cost management, schedule management, and other project management criteria. However, when the construction was completed in May 1st, 1931, the building was not being rented out as expected and by 1933, only 25% of the building was rented and 56 floors were vacant. In this sense, the ESB project can be viewed as a failed project in terms of product, and investors perceive it to be a representative failed and unsatisfactory project (Tauranac, 1995).

Evaluating and measuring project success and customer satisfaction is difficult as it can be perceived in different ways. Other than the quantitative indexes, such as cost and schedule, qualitative indexes, such as reliability, individual empathy, positive assistance, etc., are also a very important factor that determines customer satisfaction.

2.3.4 Correlation between PCA and Customer Satisfaction

PCA takes a very important role for project success. PCA takes a construction project prior to construction to determine whether the design is complete and aesthetically appealing, and systematically simulates whether the project cost, schedule, quality, and other owner's requirements are within the scope based on the design. Then, competent designer, constructor, suppliers, who will carry out the project are selected to form the project team. The task of having a good design and a good team itself is a barometer for project success. A competent team that is capable of performing PCA is more important that whether PCA is performed or not. For projects that implemented PCA, the owner's commitment and philosophy, and especially the support of the owner, is important. It is difficult to have a successful project with a low-cost designer and low-budget constructor.

If PCA, under the support of the owner, is being performed by a competent team, construction phase, that proceeds preconstruction phase, should be carried out without any issues. As such, the project will succeed and will lead to a satisfied customer, creating a virtuous cycle. Construction projects have a very strict relationship. In other words, you harvest what you plant. That is the reason why value for money or value-oriented construction becomes a major topic in Construction Innovation Movements for western countries such as the UK or the US. It is very likely for PCA to acquire customer satisfaction if PCA was performed by a competent team.

Customers (repeat customers) who have performed multiple construction projects perceive high satisfaction during the planning and design stage compared to that of new customers (Jeong, 2011). This is because the customers understand the importance of preconstruction phase in a project. According to Maloney (2002), cost and schedule is the most important factor in a construction project for the client and achieving it will bring satisfaction to the customer. Periodical review of the project during the design phase to check if the project is within the budget and if there are any alternatives in order to enhance the quality and performance are factors that determine customer satisfaction (Tang et al., 2003; Jeong, 2011).

As shown in Figure 2-8, customer satisfaction for each phase of a construction project depends on various factors and relationships. Nevertheless, customer satisfaction during preconstruction phase of a project has a significant impact on the overall satisfaction of a customer.

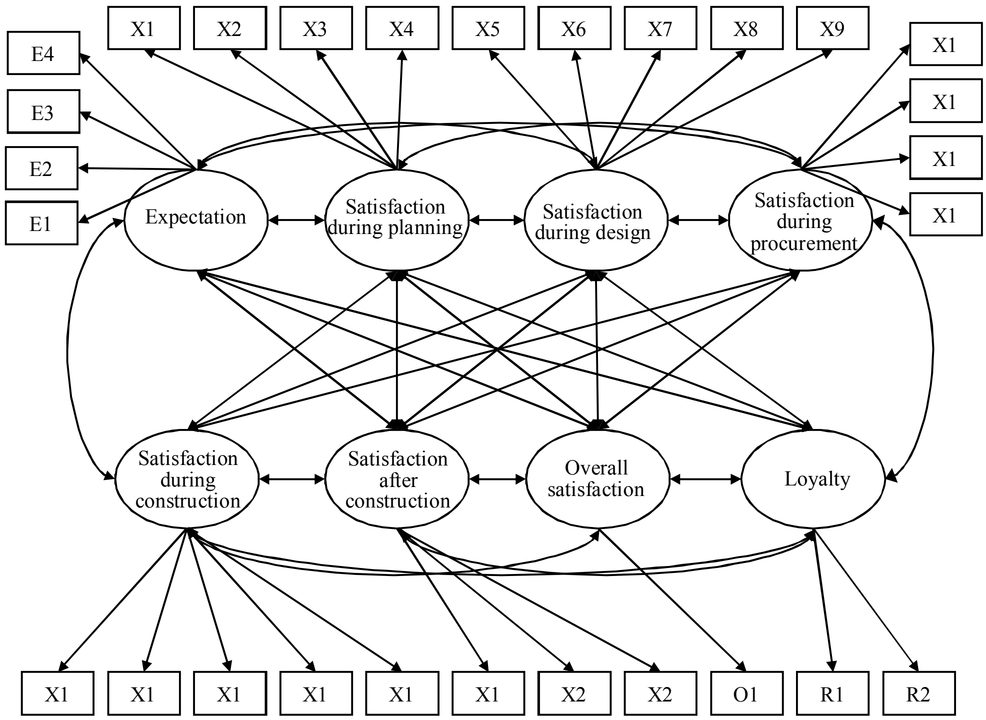
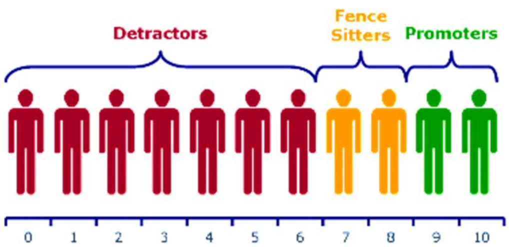


Figure 2-8 Causal link of factors effecting customer satisfaction (Jeong, 2011)

2.4 Customer Satisfaction and Net Promoter Score (NPS)

2.4.1 Summary of Net Promoter Score

Reichheld (2003) analyzed a number of company case studies and developed an index called Net Promoter Score (NPS) to determine how loyal a customer is. NPS involves one simple question of “how much are you willing to recommend this product or service to a friend or colleague?”. This one question can determine how much a customer is loyal to the company, and it is the one number needed for a company to grow. NPS is scaled from 0 to 10, and 0~6 are detractors, 7~8 are passively satisfied, and 9~10 are promoters (Figure 2-9). Equation to determine NPS negates the passively satisfied (7~8) and is the difference between the percentage of promoters and detractors. Theoretically, NPS can range from -100 to +100 points, and there are many cases in which a company scored a negative NPS. This points out that it is not easy to achieve an NPS of 50 points (Table 2-4).



NPS = Promoter(P) % - Detractors(D) %

Figure 2-9 Net Promoter Score

Since NPS survey is very easy to conduct (only one question) and a very powerful tool in measuring customer loyalty, there are many cases by global companies that have utilized it but there are scarce examples by construction companies.

Table 2-4 Example of NPS Calculation

Group	**Respondent Score**					**NPS**	**Calculation Method (Promoter % - Detractor %)**
	1	**2**	**3**	**4**	**5**		
(A)	10	9	⑧	6	5	0	40% - 40%
(B)	10	10	10	6	5	20	60% - 40%
(C)	10	10	9	⑧	6	40	60% - 20%
(D)	10	10	10	⑧	⑦	60	60% - 0%
(E)	10	⑧	⑧	6	6	-20	20% - 40%

※ Only passively satisfied are marked with (O), Promoters are between 10~9 points, detractors are between 0~6 points. For easy understanding, each group is composed of 5 respondents (1 response = 20%)

2.4.2 Customer Satisfaction and Customer Loyalty

Management of customer satisfaction is different from business types but rather a key management activity in order to achieve sustainable company growth. There is no company that can exist without any customers and iff the customer cannot be satisfied with the quality, performance or service, the company is likely to lose business which can have a catastrophic financial damage (Reichheld and Sasser, 1990; Reichheld, 1996). On the other hand, promoters are likely to repurchase and through positive word-of-mouth, it can help the company to gain new customers, which is why it can be considered as an important factor in the construction industry (Torbica and Stroh 2001; Maloney 2002, Jeong 2011). Reichheld (1993) stated that the success of a company is about a customer staying with them for a long time. Also, for the credit card company MBNA, by increasing the customer retention rate by 5%, an increase of 60% in profit was realized.

Pareto Law that was introduced by the Italian economist, Vilfredo Pareto, states that "20% of Italy's population holds 80% of the nation's wealth". Even today, many marketing examples show that the top 20% of the customer accounts for 80% of the total revenue, which is the rationale for VIP marketing strategies (Yoo, 2016). Pareto Law is not only applied to company revenues but also, profit and loss, customer satisfaction, human resource, and other areas, and is the foundation for key customer theory. It is plausible to apply Pareto Law to loyal customers as well.

Guenzi and Pelloni (2004) mentioned that customer satisfaction leads to customer loyalty, and Heightchew (1999) said that loyal customer due to satisfaction is the biggest asset of a company, and maintaining such loyal customer is much more beneficial than acquiring new customers. It is definitive that a loyal customer is the most important factor that effects company growth. According to Reichheld (2003), although NPS may not guarantee growth, it is not possible to grow without loyal customers.

2.4.3 Relationship among Customer Loyalty, Referral Intention, and NPS

Reichheld (2003) stated that loyal customers talk up to friends, family and colleagues, and that recommendation by loyal customers are one of the best indicators of loyalty. He also pointed out that it is the loyal customers that are capable of recommending and providing the company with more value that what the company had offered. Furthermore, he explained that there is a very close correlation between satisfaction and referral intentions: higher satisfaction level yields to stronger referral intention. Construction-related business is contracted by a limited number of customers, and such contracts are outsourced or subcontracted to another who has been in business for some time. Since there is no objective standard on the outcome itself and solely depends on the subjective decision of the owner, it is extremely important for a construction company to acquire loyal customers. Loyal customers are likely to have repeat orders and further recommend family, friends and colleagues for the company's service, which will be a new order for the company. A customer with strong loyalty is likely to provide a high NPS resulting in the company to maintain a high NPS as well. Positive word-of-mouth effect is very important in the construction industry and has a large role in selecting the desired company.

If PCA is performed as planned, the construction process will proceed without any issues, the project will be more likely to succeed, and ultimately the customer will be satisfied. Then the virtuous cycle of the satisfied customer referring the product or service to family or friends will occur. Since the outcome of construction is usually for the owner's use or owner relative facilities, the owner has a significant affection towards the project. If such project succeeds, then it is only natural for the owner to recommend to his/her acquaintance. Also, it is human nature to recommend and boast about the participants who provided service throughout the process.

Construction must have a process in which the correlation between input and output is very strong. Therefore, without proper preparation and planning, and design with completeness, it would not be reasonable to expect an outstanding outcome. The virtuous cycle is achievable only with proper PCA: competitive design → competitive and high quality construction → project success → satisfied customer → high NPS.

2.5 Summary

This chpater reviewed the concept and categorization of PCA, the concept and contents of design management which is the core of PCA, and analyzed previous studies concerning customer satisfaction and NPS. The summary of this chapter is the following:

(1) The difference in project management PCA category system between CMAA's construction management standard of practice (CMSP) and PMI's Project Management Body of Knowledge (PMBOK) was reviewed. Then PCA was defined. Pre-design phase and design phase that composes PCA is also discussed. Also, difference of PCA is shown in a chart by comparing

with constructor-centered PCA (PCS). Finally, the similar concepts, FEP and PPP, are reviewed and its difference with PCA is discussed.

(2) The concept of design management was introduced and the difference between design review and design management was studied. DM covers not only the aesthetic factors but also the functional factors including cost, schedule, quality, construction method, construction details etc., during the design stage in order to increase the overall design quality and completeness. If IPD is implemented during design, it is possible to shorten the design phase, reducing the overall project time.

(3) Partnering and IPD was introduced in order to find a more efficient and performance-centered PCA after reviewing PCA and best practice methods. The framework of the Primary Supply Chain Members form the UK's innovation program, ProCure 21, was reviewed and contents and beneficial factors of IPD were also studied.

(4) In order to analyze the correlation between PCA and customer satisfaction, types of customer in the construction industry was first discussed. The theory of customer satisfaction in construction and the need for customer satisfaction in construction was further reviewed. Also, after the difference between project success and product success was analyzed, and the importance of both the product success and project management success was further discussed. The correlation between PCA and customer satisfaction was analyzed. Although customer satisfaction has a causal relationship for every phase of the construction project, this research utilized previous research which proved

that the activities during the preconstruction phase effected the customer satisfaction the most.

(5) Relationship between customer satisfaction and NPS was reviewed. First, the concept and calculation method of customer satisfaction and customer loyalty was discussed. The importance of loyal customers was also discussed in terms of quantitative values. Also, the correlation between customer loyalty, and referral or NPS was analyzed. Finally, the importance of positive effect of word of mouth and customer's recommendation of service in the construction industry was discussed.

(6) The uniqueness and differentiation of this research is discussed by reviewing the limitations of previous studies and the differentiation of this research. In order to overcome the limitations of previous research this research attempts to address the major issues of ① lack of knowledge on PCA, ② customer dissatisfaction due to lack of PCA performance, and ③ lack of verification system on PCA, which are addressed utilizing research from not only construction but other industries. This research also suggests a cycle model among the keywords of PCA, schedule reduction, customer satisfaction, and NPS, through in depth research and logic. However, as there are limited amount of research concerning the keywords, some knowledge are based on the author's experience. This can also be said to be another point that differentiates this research from others.

Chapter 3. Best Practices on PCA and Schedule Reduction

This chapter will discuss on the method to decrease construction schedule through PCA based on the literature review on Chapter 2, which includes the concept of PCA, PCA and design management, PCA and customer satisfaction, and customer satisfaction and NPS. After, the Empire State Building example is utilized as a case study and further analyzed in order to prove that it is possible to decrease schedule through PCA. Then, issues with the current schedule management in Korean construction projects are identified. Based on the studies, the method to decrease schedule utilizing PCA is further discussed along with a conclusion.

3.1. PCA and Schedule Reduction

3.1.1 Examples of Schedule Reduction based on PCA

According to Subbiah (2012), actual construction was one month ahead of planned schedule due to preconstruction planning, in which PCA contributed to the successful construction of the London Olympic Stadium. Based on CMAA Construction Management Standard of Practice (CMSP) (CMAA, 2015), time management schedule management is carried out during the pre-design phase to establish a master schedule and milestone schedule, and during the design phase, the master schedule and milestone schedules are managed along with the design schedule. Also pre-bid schedule is managed in preparation for the procurement phase. By managing the contractor's construction schedule during the procurement phase, schedule management for construction is prepared. As such, by systematically managing and monitoring the schedule for each phase as well as utilizing a management system and tools for the task, it will be possible to decrease the fluctuation of the project duration and the project duration itself. As mentioned before, Subbiah (2012) views the project success of the London Olympic Stadium as a result of preconstruction planning. Furthermore, considering PCA verifies cost, quality, and constructability for each phase before construction, it is possible to reduce errors or rework resulting in decreased project duration. Lines (2014) proved that for small projects ranging from $500k to $1.5m, whether pre-contract plan existed or not had a significant effect on the project performance. Within 21 days of performing pre-contract planning, a project was able to decrease cost (cost increase) by 54.9%, schedule (schedule delay) by 70.4%, and increase owner's satisfaction by 33.7%. PCA is a process of perfecting the professional service (design drawings, etc.) in order to create the hardware (construction), and a method to create competitiveness of the project. Also, in the early stage of the project, should the owner have a special request or the project require schedule reduction, a team can be formed during the preconstruction phase to carry out PCA in order to achieve the desired goals effectively.

For example, WinSun, a Chinese company, stated that they had implemented 3D printing at the Suzhou Industrial Park, east China's Jiangsu province, to erect a 5 floor high apartment in 6 days (3DPrint.com, 2015). Broad Group, also a Chinese company, stated they had developed a Broad Sustainable Building (BSB), a factory manufacturing system to erect a 30 floor high hotel in 15 days. Also, the Empire State Building, 102 floors high building built in 1930s, was completed within 13.5 months. In the early 2000s during the IT bubble, an IT company constructed a distribution center with an area of 20,000m^2 without any drawings in 3 months. There are much more unconventional and unique projects that have been completed and the question of how fast a project needs to be completed is absolutely based on the support of the owner in planning and the competency of the project team. It is well known that the Empire State Building had not only decreased schedule but also decreased the overall construction cost by $2m (currently about $116m) which makes it even more of a successful case (Wills and Friedman, 1998).

3.1.2 Trade-off Relationship between Schedule Reduction and Cost

However, for such projects with very short duration, cost and schedule reduction has a trade-off relationship. In order to push the construction work, it requires cost acceleration. Nevertheless, the added value the project creates by being completed within a short duration exceeds the cost acceleration. Although an extreme case but when Macao, China, abandoned the casino monopoly in 2001 and opened the casino market, the initial investor was the Sands Group from Las Vegas, USA. When the Sands Group decided on investing $300 million on Macao Sands Casino, the feasibility study report stated that it will be possible to reclaim the investment in 1 year 6 month time. As such, the construction was fast-track and the casino was completed within a very short time. Once the casino was in operation, business was much better than estimated and within 6 months of opening, they had already reclaimed their investment. As a result, the group invested another billion dollars in another large-scale project in Macao, and another project in Singapore called the Marina Bay Sands.

Such case, where the decrease in project duration is directly linked to profitability, is a familiar concept to foreign expert investors. The possibility of achieving it depends on the owner's commitment and leadership, PCA and planning, and a good team.

There are also many best practice cases that defy the trade-off relationship. Rethinking Construction, one of the most influential reports on UK construction industry, established 7 core agenda (Table 3-1) for innovation, which were to decrease construction time and capital cost by 10%, increase productivity by 10% in order to increase construction profitability by 10% every year (Egan, 1998). Then, through demonstration projects best practice cases on cost and schedule decrease were created.

Table 3-1 Rethinking Construction 7 Core Agendas (Kim, 2006)

Core Agenda	Yearly Goals
Capital cost	-10% (reduction)
Construction time	-10% (reduction)
Predictability	+20% (increase)
Defects	-20% (reduction)
Accidents	-20% (reduction)
Productivity	+10% (increase)
Turnover & profits	+10% (increase)

3.2 Empire State Building (ESB) as a Best Practice Example

In this section, the Empire State Building (ESB) that has created a remarkable record for the construction of high rise buildings will be analyzed in depth and how PCA contributed in the project success will be discussed.

3.2.1 Summary of ESB Project

(1) Remarkable Record

Once the first steel column was erected in April 7^{th}, 1930 for the ESB, it only took 6 months to complete 86 floors with more than 57,000 tons of steel. Although the ESB is 102 floors, it can be occupied only up to the 86^{th} floor, which is why the construction for most steel structure was completed. During the period when the ESB was constructed, tower cranes were not developed and a derrick, which is inferior in efficiency, was used. Also, because the concrete pump car was not yet invented, manpower and hoists were used to transport and pour the concrete. As such, the conventional construction method for ESB makes its performance much more significant (Kim, 2014). Also, after the first erection of the steel structure, the construction of ESB was completed in 11 months, an astonishing speed for construction. On March 1^{st}, 1931, 1.5 months before the construction completion ceremony (Willis and Friedman, 1998), the actual construction was completed but the ceremony was held on May 1^{st}, 1931 as planned. Based on the completion ceremony, the construction took 13.5 months in total. The construction site operated 8 hours per day, 5 days per week without any overtime or weekend work and continued structural work for each floor per day. On August 1930, within the 22 workdays, 22 floors for structural work were completed (Kim, 2014). Once the ESB was completed, it continued to be the world's tallest building for the next 42 years.

In general, the construction cost would increase because of acceleration cost when attempting to decrease construction time. Nevertheless, through systematic cost management and PCA, construction cost of $2 million was saved and it was completed for \$25 million[5] (Willis and Friedman, 1998). Furthermore, the construction speed of ESB is still yet to be broken (Sacks and Partouche, 2010). Partouche et al., (2008) analyzed 28 tall buildings ranging from 1914 to 2007 and plotted the average rates of construction in terms of number of floors and square meters per year of construction. As shown in Figure 3-1, the construction speed of ESP is overwhelmingly faster compared to other buildings and the overall construction speed had rather declined over time.

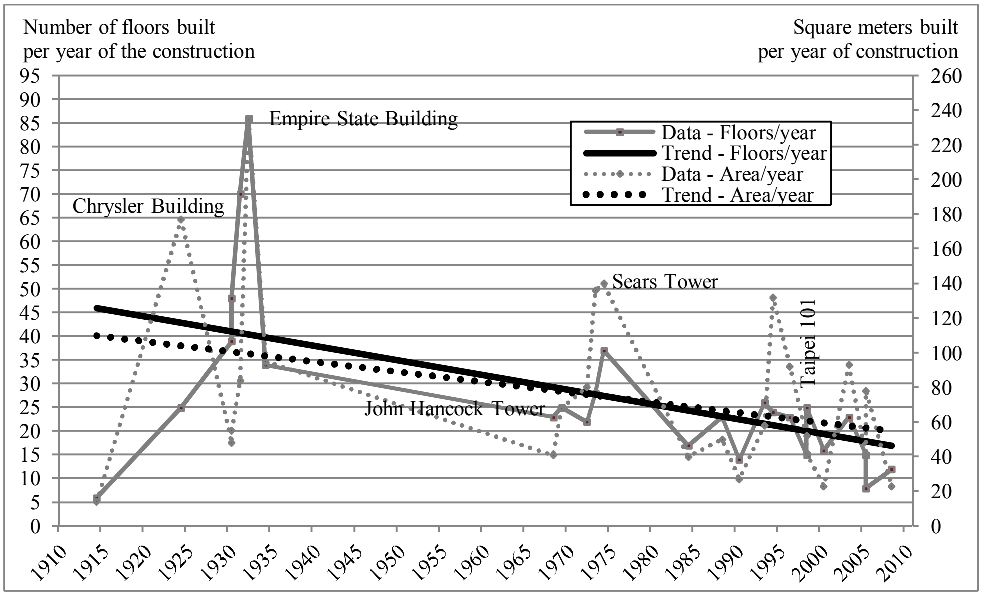


Figure 3-1 Construction speed (in floors and area built per year) in tall buildings around the world 1914-2007 (Partouche et al., 2008)

(2) State of the ESB Period and Project Success Factor

The Great Depression was taking place during the construction of the EBS, and therefore, acquiring manpower, equipment, and material was stable (Sacks, 2010). During the early 1900s, construction companies did not allow half of the manpower

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[5] Converted to today's currency, \$1,460 million; construction cost \$25,000,000 ÷ total area 254,000 ㎡ = \$98.4/㎡
Current NYC high rise prestige building construction cost \$5,748/㎡(Turner & Townsend data)
Increase of approximately 58.4 times, \$25,000,000 x 58.4 ≒ \$1,460 million

to be composed of sub-contractors as seen in the EBS construction. Allowing sub-contractors for the construction of the ESB, it was possible to decentralize authority and management. Sub-contractors were able to utilize their expertise and coordinate with other sub-contractors freely (Tauranac, 1995). In today's terminology, the constructor of the ESB had the role of a construction manager (Parkyn, 2002).

The success factors for schedule management in ESB was ① team design approach and ② the genius constructor (Willis and Friedman, 1998). For team design approach, the architect, owners, builders, and engineers plan all together to resolve issues to make major decisions before the design. In other words, PCA due to team design approach was the first success factor.

For the organizational genius of the constructor, Starrett Brothers and Eken was the constructor for ESB. They had a principle of not participating on a project if they were not able to manage the very beginning of a project, proving their knowledge on the importance of PCA. Bill Starrett, the youngest among the Starrett Brothers, was a colonel who participated in the First World War as the Head of Emergency Construction Section of War Industries Board. He gained experience of constructing bases, hospitals, flying fields, and other facilities for 1.8 million soldiers in a super-fast speed. He also accomplished the construction of a large-scale barracks in 90 days (Tauranac, 1995; Willis and Friedman, 1998). There are also a number of office building projects that were completed in a short period by the same company. Among which, the Bank of the Manhattan Building, completed in 1928, is a large building with a total area of $839{,}351m^2$ and 70 floors tall. The building was completed in 11 months, as if it was a rehearsal for the ESB.

The leadership of John Jacob Raskob, major investor for the construction of ESB, and problem solving capabilities of Alfred F. Smith, ESB CEO and former New York governor, were another success factors. They were able to select an outstanding project team and through competent and on time decision making, they were able to take the role as a project owner very successfully.

Another success factor was the excellent design and coordination skills of the architect, Shreve, Lamb and Harmon. The architects led the fast-track method by using simple details for the design, and performing both design and construction simultaneously for a speedy construction. Paul Starrett, the eldest of the brothers, praised the architects highly for their achievement after the construction was completed. He stated that there has never been and will never be a design that is so well adapted to the speed of the construction (Tauranac, 1995). In conclusion, the success of ESB was due to the leadership of the owner, competent designer, and excellent constructor who planned and performed decision making together from the beginning stage of the project to solve issues together under the team work approach. In other words, it was a successful PCA from the early stage of the project and through early involvement of the constructor, all the stakeholders were partnered to achieve a single goal which was the success factor of the ESB.

3.2.2 Characteristic Analysis of the ESB Construction

ESB construction project was a new chapter for tall buildings. It is also a phenomenal project in which the construction speed is still unbroken. Furthermore, the ESB construction was an outcome by the project stakeholders who focused solely on the project goal and achieve the project objectives through team work.

(1) Owner's Requirement and Cost Decrease

The first owner's requirement that was provided to the designer and constructor by the owner was that the project to be completed by May 1st, 1931. Since the rent fee for the office was processed once a year on May 1st, if the project was delivered after the date, the 1 year worth of rent fee would have been a loss (Willis and Friedman, 1998). Constructors and other stakeholders understood the millions of dollars' worth of loss if the construction was delivered late, and the fact that a day loss converted to $10,000 (currently about $580,000) or more. The other owner's requirement stated to construct the world's best building under the minimum cost. Abiding by the requirements, the construction schedule was reduced (actually completed on March 1st, 1931) and cost was drastically reduced as well. The project began with $50 million budget including the $16 million for the land cost, but about $9 million of the construction expense was saved (currently about $520 million) resulting in a sum of $40,948,900 for the construction (Pearce et al., 2012).

(2) Fast Track Method and Prefabrication

The construction of ESB utilized innovative methods in most parts including design, design management, procurement, site management, logistics and equipment. There were no significant issues with such methods which resulted in the historical record in building construction. Even after 90 years today, the record is still unbroken. The construction completion target date was already decided for the ESB construction with very little time for design. As such, fast track method was implemented that allowed the design and construction to commence simultaneously. The ESB construction project is known to be the beginning of the fast track method. High design skills as well as coordination skills are necessary to manage the risks associated with the fast track method. For the ESB project, since the owner, designer, engineer, constructor all formed a team design approach, it was possible to have only 17 design changes throughout the construction period making it very successful (Ghosh and Robson, 2014).

Off-site fabrication was maximized and strongly implemented in ESB in order to reduce schedule and cost and maximized the site usage. Windows, spandrels, steel mullions, and stones were fabricated off-site and mass produced with high precision, and after, the parts were assembled on site (Tauranac, 1995). There were only eighteen variations for the metal spandrels, in a total of 5,704 parts (Partouche et al., 2008). Rolled wire mesh was used for the floor slab instead of rebar which drastically reduced the time needed to layout the rebar (Willis and Friedman, 1998). The four pacemakers which are known to be the key success factor in the ESB construction schedule management were ① structural steel erection ② concrete floor arches ③ exterior metal trim and aluminum spandrels (curtain wall), and ④ exterior limestone. Since the construction work for the four pacemakers occurred as if on a conveyor belt without a single error, it was possible to shorten the planned schedule (Table 3-2). As a result, once the structural and exterior works were completed ahead of schedule, and electrical, mechanical and other works were able to commence immediately. As the façade was completed early, it was possible to continue construction indoors during the harsh winter.

In the end, the construction schedule was decreased comparatively to the planned schedule and it was possible to complete the construction by April, 1931 (Tauranac, 1995). Regardless, the owners held the grand opening ceremony on May 1st, 1931 as planned.

Table 3-2 Schedule Comparison of Four Pacemakers (Tauranac, 1995)

Trade	Scheduled Date	Actual Date	Time Saved
Structural Steel	October 4	September 22	12 days
Floor Arches	October 10	October 6	4 days
Exterior Metal	December 1	October 17	35 days
Exterior Stone and Backup	December 1	November 13	17 days

(3) Best Practices

There had been many attempts to decrease the construction schedule as well as a number of best practices applied for the construction of ESB. There are also numerous examples that provide insight on how to view construction, what to prepare in order to decrease schedule, and what type of philosophy is required. Implementation of prefabrication and fast track method, lean construction and mass construction, concepts which did not exist at the time of ESB, were also implemented. Lean construction was a concept that began in 1990s by Toyota to enhance their productivity. It was then further applied to construction to optimize the construction process, minimizing waste, adding value, and providing a smoother workflow (Thomsen 2009). The theory of lean construction began in 1990s and is still developing, but it had already been used on the ESB construction during the 1930s. The key concept of lean construction for ESB can be summarized as the following. ① all materials arrive just-in-time; ② all arrived materials are transported only once; and ③ all materials must be used within 3 days of arrival. The principle behind the logistics management is very similar to a train's arrival and departure at the Grand Central Station (Willis and Friedman, 1998). Concept of lean also includes standardized design, prefabrication and minimizing worker travel (Sacks and Partouche 2010).

Another best practice for the ESB construction was mass construction. With a total floor area of 257,211m^2, this 102 floor building included 57,480 tons of steel structure, 48,000m^3 of concrete, 10 million bricks, 6,400 windows, and mobilized 3,500 manpower during peak time (Sacks and Partouche 2010; Willis and Friedman 1998). In order to complete the project with large quantities of resource within a year, a new type of management such as project management or product management was necessary. Similar to the concept of lean, the concept of mass construction had already been applied to the ESB construction before it was established as a concept. The initial concept of it was to operate the four pacemakers like a factory assembly line (Willis and Friedman, 1998). This concept also relates to the fact that the major investors, John J. Raskob and Pierre Dupont were high ranking executives at General Motors.

According to Sacks and Partouche (2010), the characteristic of mass construction system for the ESB were ① Multiple uniform & repetitive spaces & modules, ② Work flow planned TAKT time, ③ carefully designed logistic systems to deliver materials, and ④ standardized work. As seen in Figure 3-2, the steel structure is in progress on the 35th floor and concrete slab floor arches are completed 3~4 floors below. Exterior metal is in progress 9 floors below and the exterior stones and windows are completed 6 floors below. The structural work and external work, a part of the four pacemakers, are forming an assembly line and driving the mass construction system. The speed of the construction site continued steadily throughout the construction period without any errors. A peculiar point is that there is no tower crane, as it was before tower cranes were developed. Instead, there are a number of derricks and hoist on the upper floors of the building construction.

Figure 3-2 Construction View of the ESB

(4) Logistics and Construction Equipment

According to Willis and Friedman (1998), the primary key to success for large scale construction projects is always logistics. The logistics plan that supported the flow of materials and manpower was near to perfection even at today's standards. During the peak of the ESB, sufficient mine cage lifts and elevators were installed to move the 3,500 manpower that were mobilized. To minimize worker's travel, adequate numbers of cafeterias and temporary toilets were installed. This maximized the efficiency of the workers and minimized the travel time during the construction of this tall building. The concrete batch plant was installed on the first basement floor where concrete was produced and distributed. 9 derricks were installed for the rebar installation and 2 extra derricks were installed to lift the equipment. 17 various hoists were used to transport materials, located to optimize the vertical transportation of steel bars and materials. The result of the planning was a construction cycle of 1 floor per day. The steel structure was fabricated at a plant located 440 miles from the site at Pittsburgh. For 10 thousand tons of steels to be erected every month, a special logistics plan was necessary to deliver this massive quantity of material. The solution was to utilize the Hudson River, thus avoiding the traffic congestion at the heart of the city, to unload the materials close to the construction site, and utilizing trucks to deliver it to the site (Tauranac, 1995).

3.2.3 ESB Construction and PCA

(1) Team Design Approach

From the beginning of the ESB project, the owner's requirement had a very clear goal of completing the building by May 1st, 1931. Therefore a competent team that can accomplish this goal was required when selecting the designer and constructor. Based on the goal, the designer was selected on September 1929, and within 20 months the construction was completed. The owner's selected the constructors within two weeks of selecting the designer before the concept drawings were complete (Tauranac, 1995) and integrated the design and construction by involving the constructor early in the project. Then, a Policy Committee on design and construction was immediately convened. This committee involved the key personnel from the owner, designer, and constructor who had multiple meetings per week to make the vital decisions. This committee also approved the floor plans, exterior, and other major decisions (Tauranac, 1995; Willis and Friedman, 1998).

(2) Roles of the Contractor as a Construction Manager (CM)

The constructor of the ESB project, Starrett Brothers & Ekin, had the role of construction manager, different from that of a general contractor. They stated that they will not participate unless they are involved early in the design stage of the ESB. Also, a flat fee of $500,000, exclusive of any other contracts concerning the total construction cost, was requested before construction began. Therefore, it is possible to say that they had a role as a CM. They had the capabilities of performing design work and Paul Starrett, who completed a large scale barrack in 90 days while he was in the military, was an expert in super short construction. Also, they had the experience of completing the 70 floor Bank of the Manhattan Building in 11 months with obvious excellent skills in schedule and logistics management. They also had the ability of estimating cost without the drawings which is a very important factor in construction management. Therefore, they were able to perform PCA by making important decisions based on the estimated cost and drawings. They also aggressively performed VE (terminology that did not exist at that time) to decrease the cost. Most of the activities of the Policy Committee were led by the constructor who took the role as a construction manager.

Examples of PCA that contributed to the excellent performance are the following (Tauranac 1995). ① There was a department store planned on the lower floors during the early design stage, but since a department store required a large open space and is prone to a lot of design changes which will affect the budget and schedule, it was cancelled. ② Terracotta was very popular at that time and was suggested. However, the building was finished with stones on the basis that defects in terracotta that may arise in the future. ③ In the early design stage, stone finishing was applied to the first five lower floors and others were finished with bricks. However, since bricks are expensive and slow, this was changed to limestone. ④ Around the time when the ESB construction was beginning, New York City was preparing to change a steel bar code from 16,000 pound per square inch (psi) to 18,000 psi. Despite the gap between the construction and the change in the code, the ESB team calculated the risk and designed and prepared the drawings for 18,000 psi resulting in a decrease of 10~12.5% steel structure and 15~20% in steel cost, a total saving of $500,000 (currently about $29 million). ⑤ As many parts as possible were prefabricated at the factory and assembled on site. The designer put as much effort in on the smallest and simplest details to decrease the construction schedule as well.

(3) Quick Decision Making and Problem Solving

The Committee members understood the importance of PCA at the early design stage. As such, they reviewed the cost, schedule, constructability, and quality for issues and incorporated the final result into the drawings; probably the first attempt to integrate modern design with construction. Figure 3-3 compares the trouble shooting process between traditional design issues and the ESB's problem solving process. As such, quick decision making was possible for the ESB due to the competent designer and constructor having the full support of the owner, which further contributed to the project success. Through PreConstruction Activities, all important issues are reviewed thoroughly and then executed (Willis and Friedman, 1998).

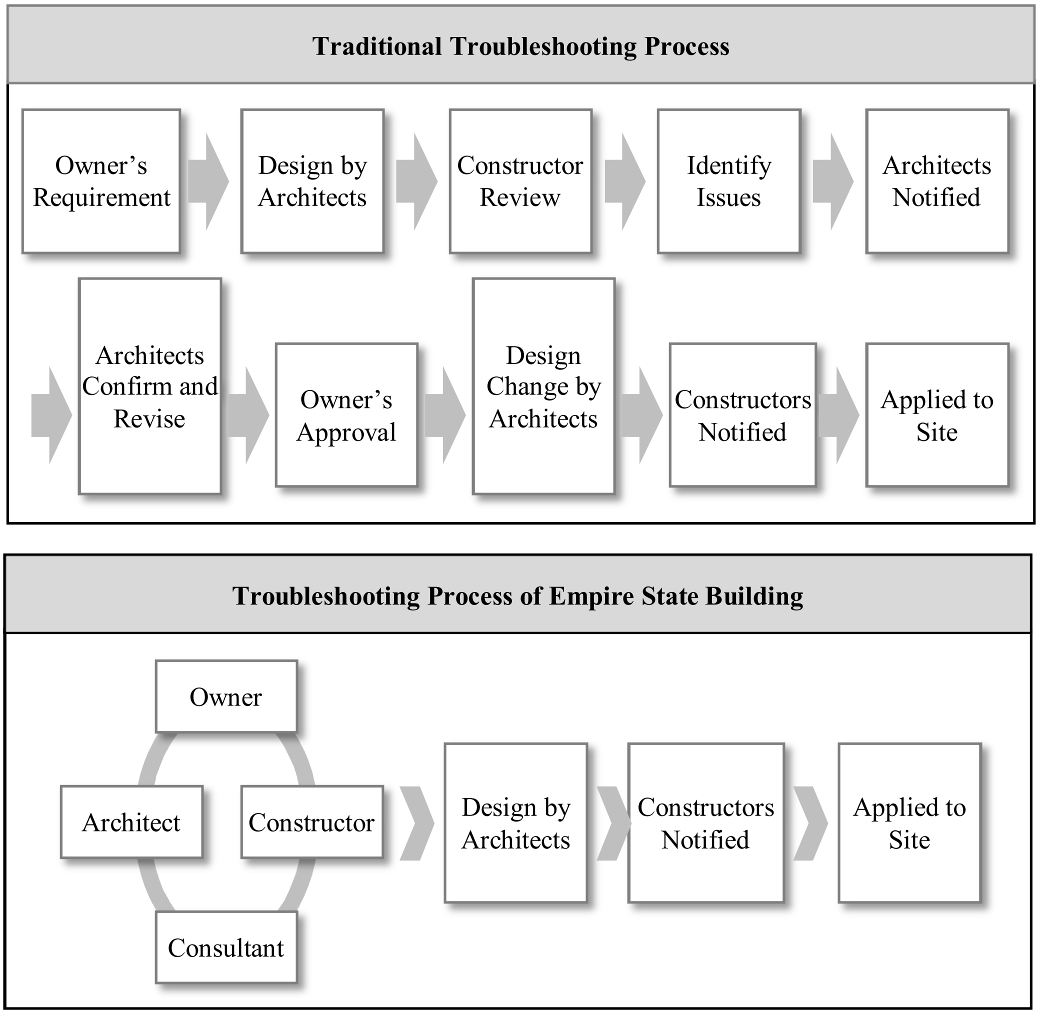

Figure 3-3 Trouble Shooting Process

(4) The ESB Success Factors and Implication Analysis

The overall success factors of the ESB and its implications are the following:

① Owner's leadership

The owner's requirement was specific, such as completing by May 1^{st}, 1931, and the constructor, designer and other contractors were selected to create a best team and to make all the major decisions. The project execution philosophy and strategy was unique for its time.

② Genius Constructor and Skilled Designer

The project was carried out by a constructor who had great knowledge in design, construction and cost, and took on responsibility similar to that of a CM. The constructor also had the experience and skills to reduce schedule. The designer had the insight of realizing that a prefabricated design is much more beneficial in a fast track project.

③ Partnering had been established between the owner, designer, and constructor through the team design approach, and systematic PCA was performed. Furthermore, prompt decision making had been achieved.

④ The 4 pace makers, steel structure, concrete work, curtain wall, and exterior stone walls were systematically managed to operate similar to a conveyor belt in a factory making a 1 floor per day cycle possible.

⑤ Construction equipment and logistics plan was perfectly executed. As a result, materials and equipment were well delivered, manpower was effectively moved and the concept of lean construction and mass construction was implemented perfectly in the project.

⑥ Schedule reduction and cost were reduced simultaneously, which negated the trade-off relationship between cost and schedule.

Overall, the success of the ESB was due to the teamwork with the construction participants as well as the success of PCA.

Implications of the ESB best practice and other foreign schedule reduction examples were analyzed. The result on analyzing the schedule management issues in Korean projects was that various methods to decrease construction schedule in various situations exist. However, just as if the key to a project success lies in the owner, the owner has a significant role in schedule reduction. The key to project success and schedule reduction lies in the early stages of a project, in which PreConstruction Activities are imperative for project success.

3.3 Issues with Schedule Management in Korean Projects

In this Section, the common understanding of the Korea construction project schedule and issues with schedule management is examined. Then the phenomenon of the Korean construction schedule is determined by comparing the schedule with other countries. Finally, the hypothesis on whether PCA can contribute to schedule management, or even extend to schedule reduction is discussed.

3.3.1 Comparison of Construction Time for Major Countries

(1) Construction Time per Floor

Comparing the construction time for the US, Japan, and Korea, there are many factors that affect the schedule, such as project type, total floors, and number of basement floors, but it is possible to determine the rough trend of the construction time. The US was 10.5~16.9 days, and average of 12.6 days per floor; Japan ranged from 15 days to 25.7 days, an average of 20.3 days; Korea ranged 29~35 days, an average of 31.2 days. It is possible to conclude that the construction time in Korea is 2.5 times longer than that of the US and 1.5 times longer than that of Japan (Table 3-3). The Empire State Building (ESB), a 102 floor building which began construction in 1930 and completed in 13.5 months took approximately 4 days per floor including the finishing works. Comparing ESB to the Lotte Super Tower, which took 69 months excluding earth works, Lotte Super Tower (123 floors, 555 m high) took 5.1 times more construction time.

(2) Time Required to Complete Construction after Structural Work

In Table 3-3, it is worth noting the time needed to complete all construction after the structural work has been completed. Since the tenant work or fit-out is considered as a separate construction in the US, it would be unjust to directly compare. Even so, construction can take up from 2 months to 8 months, an average of 3.5 months to complete construction after structural work in the US. In Japan, it ranges from 6 to 10 months, an average of 8 months, whereas Korea takes 9 to 15 months, an average of 10.7 months. These figure show than Korea is 3.1 times longer than the US and 1.3 times longer than Japan, which signifies that the structural and finishing work is performed similarly in the US and Japan. This finding indicates that there is still a significant amount of issues in the Korean schedule management that can be improved. As a reference, the structural work for the ESB was completed in 6 months and construction was completed after 5 months, recording a total of 11 months of construction after the structural work began. This record is still unbroken to this day (Wills & Freidman, 1998).

Table 3-3 Construction Time Analysis for High-rise Buildings (Kim, 2000)

	No	Project Name	Total Floor Area (m^2)	Levels		Structure	Total (month)	Earth (month)	Structural (month)	Completion after Structure	Cycle Time (Day/floor)	Remarks
				Base	Super							
USA	1	Texas Commerce Tower, Houston	188,958	B4	75	Composite	32	11	18	3	12.2	
	2	Allied Bank, Houston	193,686	B4	71	SRC	30	9	15	6	12.0	
	3	Cadil/Fair, Chicago	126,158	B6	62	RC	27	5	19	3	11.9	
	4	Republic Bank, Pittsburg	136,317	B4	56	SRC	21	8	11	2	10.5	
	5	Dravo Tower, Pittsburg	159,880	B2	56	SRC	22	6	14	2	11.4	
	6	Crocker Center, LA	142,973	B4	54	SRC	22	4	10	8	11.4	
	7	Hines, Chicago	148,639	B2	53	SRC	23	6	12	5	12.6	
	8	US Steel, NY	198,805	B2	54	SRC	27	8	13	6	14.5	
	9	US Steel Pittsburg	273,125	B3	64	SRC	30	12	13	5	13.4	
	10	Chase, NY	200,105	B5	59	SRC	36	18	15	3	16.9	
Japan	1	Tokyo City Hall	380,998	B3	48	SRC	36	9	18	10	21.2	
	2	Land Mark Tower	392,380	B4	70	SRC	37	11	20	6	15.0	
	3	World Trading Center	153,841	B3	40	SRC	32	13	13	6	22.3	
	4	Nomura Securities	116,236	B3	47	SRC	29	10	10	10	17.4	
	5	Kobe Trading Center	48,291	B2	26	SRC	24	7	9	8	25.7	
Korea	1	YeonBong Building	15,349	B5	17	SRC	21	7	8	6	29.0	
	2	KunJa Industry Building	29,012	B6	20	SRC	28	6	11	11	32.0	
	3	KeunGil Tower	36,506	B7	21	SRC	29	7	12	11	31.0	
	4	SunHwa Building	37,709	B6	19	SRC	29	7	7	15	35.0	
	5	DongYang Securities	42,347	B7	21	SRC	29	7	10	12	31.0	
	6	Samsung Insurance Building	86,476	B5	25	SRC	29	7	13	9	29.0	
	7	Samsung Marin & Fire	55,170	B6	21	SRC	29	7	11	11	32.0	

The Korean projects used in this comparison are relatively shorter than other buildings. Therefore, 5 recently completed office buildings over 40 floors were included and reanalyzed. Construction time per floor averaged to 23.7 days and took an average of 8.6 months after structural works (Table 3-4). Although the construction time per floor is approaching Japan's figure from 1990s shown in Table 3-3, there is still a large gap with the US.

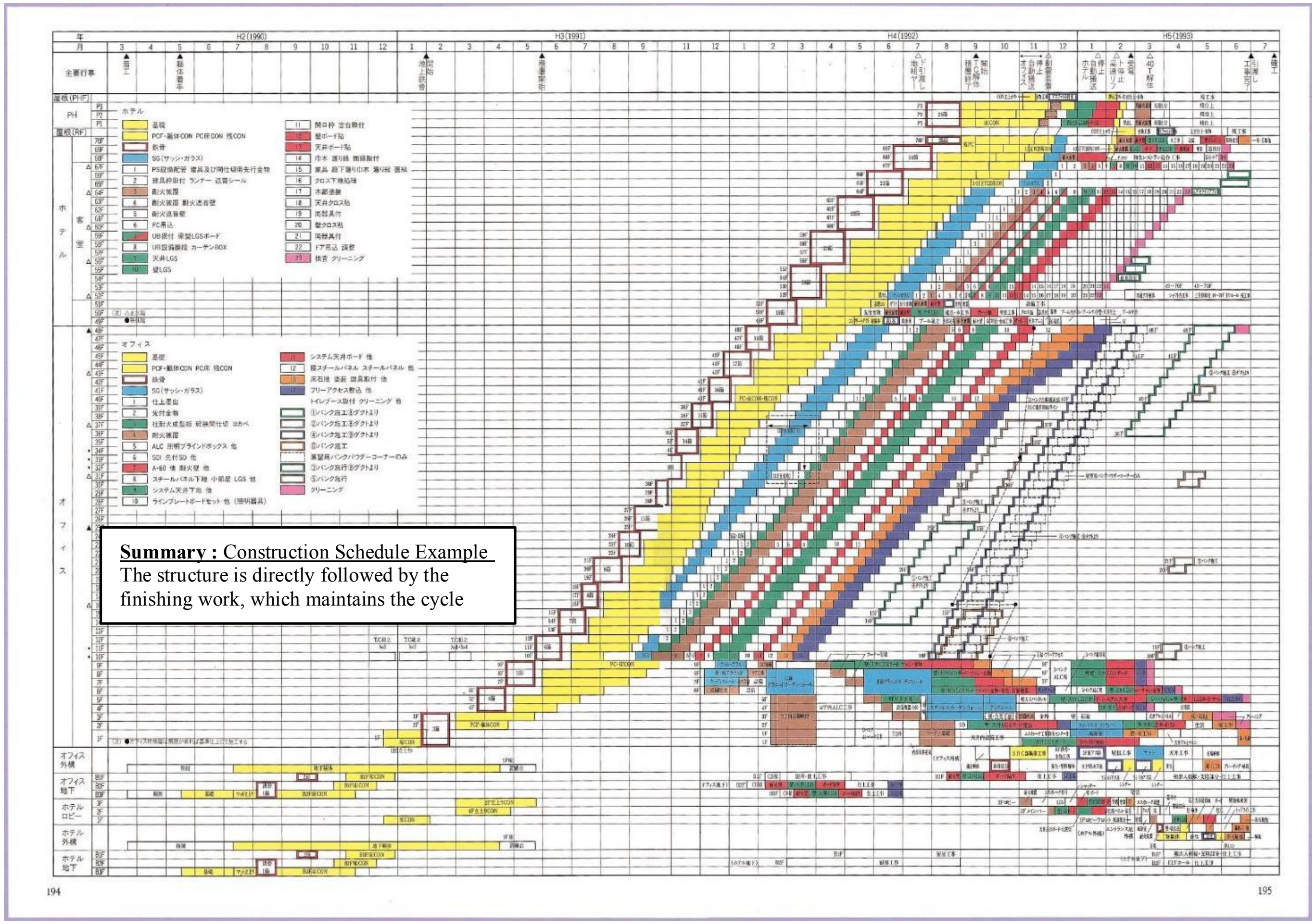

Figure 3-4 As-built Schedule for Landmark Tower, Japan (Mitsubishi Estate Co, 1994)

When reviewing the completed schedule for Japan's iconic project, Landmark Tower (Figure 3-4), it is possible to identify the schedule management model. It shows that the finish work MEP works, including the structural work are simultaneously carried out according to the line of balance. Similarly, major activities on the EBS were managed similar to that of a conveyer belt in a factory line. To develop a schedule similar to the example, intense preparation with an effective schedule management tool and necessary management skills are needed. Furthermore, a strict partnership and teamwork with the subcontractors is a must.

Table 3-4 Construction Time Analysis for High-rise Buildings 2, Korean Projects Updated

No	Project Name	Total Floor Area (m^2)	Levels		Structure	Total (month)	Earth (month)	Structural (month)	Completion after Structure	Cycle Time (Day/floor)	Remarks
			Base	Super							
1	Jamsil 2nd Lotte World	807,686	B6	123	SRC	74	5	57	12	17.08 (15.46)	(Stopped for 7 months) ACS accident, fire, structural change, method change
2	Yeouido International Financial Center	506,335	B7	50	SRC	57	10	35	12	30.00	Excluding 1st earthwork (14 months)
3	Samsung Electronics Seocho Office	197,178	B8	43	SRC	38	18	12	8	22.35	Earth/basement structure simultaneous construction
4	Songdo Northeast Asia Trade Tower	195,220	B3	68	SRC	51	8	33	10	21.55	Excluding discontinued construction
5	Yeouido Federation of Korean Industries Building	168,681	B6	50	SRC	38	15	16	7	20.36	Completed on September 2013

3.3.2 Lack of Awareness on Schedule and Issues with Schedule Management

In general, the schedule of a Korean construction project is too long compared to other western countries. For example, it would take 1 year in New York where as it would take more than 3 years in Seoul when constructing a 30 floor apartment in similar condition excluding the basement depth as it is a factor that affects the schedule (Kim, 2000). There is approximately a three-fold difference in the schedules. The question of why Korean projects require more time compared to other western countries is further discussed. The practice has been accepted for such a long period of time and Korean owners, including most engineers, do not even perceive the difference.

Attempting to understand why Korean construction schedule is too long, the first reason would be that there is a misconception that schedule reduction is bad construction practice in Korea. When bad construction is mentioned by the media, schedule reduction has always been the cause which most likely conceived the idea that schedule reduction is bad construction. Therefore, schedule reduction is seen as a negative factor and a road to bad construction practice, which is one reason why there is very little will to decrease the construction schedule.

Second, correlation between schedule reduction and cost is not well understood. Even investors, developers, and constructors do not utilize time and cost as a management point in a construction project. They do not calculate the daily cost or the monthly time cost, and therefore the cost benefit or loss of completing a day late or early is not even considered. On the other hand, western companies do manage in terms of the daily time cost at the early stages of a project to perform systematic schedule management. Contrarily, the concept of time cost is very vague in Korea[6].

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[6] Based on the calculation done by the author, considering the land cost, investment fee, financial cost, office rental fee, etc., and about $12.5 billion is being invested for the super tall building project pursued at Samseung-dong, Seoul by A-Group, each year the opportunity benefit would account for about $830 million, whereas a year of delay would cost about $830 million.

Third, there are a number of projects that have failed to abide by the planned schedule despite the long construction schedule leading to disputes with the owner and resulting in an unsatisfied customer. Schedule delays occur due to a number of reasons some of which were ① lack of project management, ② frequent requests and design changes by the owner, ③ design changes due to bad and insufficient design, ④ inability to resolve issues with the public sector (including permits), ⑤ construction sloppiness due to complaints and factors that cause schedule delay, and ⑥ lack of awareness and skills in schedule management by the designers and constructors to name a few. Therefore, the owner or the construction company has no incentive to depart from the norm of building 1 floor per 1 month + α, and they believe that schedule reduction is a risk. Hence, the schedule is estimated rather conservatively.

According to the “Comprehensive measures to improve efficiency of public construction projects” by the Ministry of Construction and Transportation in 1999, there are many public projects that have exceeded the budget and project duration. For the 7 major SOC projects pursued by the Ministry of Construction and Transportation, the project cost increased an average of 2 times whereas the project schedule increased by 3 years as shown in Table 3-5 (Kim, 2002).

It is very difficult to identify the actual cause for the issues in a public project. However, it can be summarized to be problems in the procurement system of the government and poor project management.

Table 3-5 Changes in Plans for the 7 Major SOC Project *(based on 1999)*

Type	Project Cost (million $)		Changes	
	Planned (a)	Current (b)	(b/a)	Delay
Gyeongbu Expressway	5,846.2	18,435.8	315%	5.5 years
Incheon International Airport	3,416.5	7,448.6	218%	3 years
Yeosu Airport	93.5	199.4	213%	2 years
Tamjil Multipurpose Dam	220.0	326.4	148%	1 years
Seoul Subway Phase 2-2	2,546.0	3,801.6	149%	3 years
Busan Subway Line 2	1,217.5	2,530.7	208%	4 years
Seohaean Expressway	3,180.5	4,809.7	151%	5 years
Average Increase			~2x Increase	3 years

Fourth, in case of supplier, the concept of schedule reduction being technical capability and a factor that differentiates their company with other competitors is not well established. There are no policies or incentives that act as a catalyst in pursuing schedule reduction. The formula of calculating time per floor (month + α per floor) to estimate the schedule was implemented by the housing corporation (LH Corporation). In New York, 2-day-cycle construction method is widely used, which completes a floor in two days for a concrete structured building regardless of the season or building type. It would be possible for a 30 floor building to be completed within 12 months, but if the Korean formula is applied, it would take more than 3 years to finish. During winter, there are various heating methods that could be applied but LH Corporation prohibited structural construction during winter. Recently, they have granted limited permission to construct during winter.

In addition, there are no innovative methods, cases or any form of application that can be seen in western countries to decrease construction schedule. Meanwhile, Japan has developed and is utilizing prefabricated construction or modular construction (KICT, 1995). For example, Taisei Construction developed a unique construction method called T-UP in the early 1990s. It was first used for construction of the Mitsubishi heavy industries headquarters in Yokohama, Japan. For this method, there is a travelling crane attached on top of the roof structure which is first assembled on the ground. Then an overhead crane is attached to the bottom of the roof structure to create a production line, similar to that used in a factory. A hydraulic system lifts the entire roof structure while the structure and the curtainwall of the floor beneath are completed. Since the floor by floor construction method completes both the structure and finishing simultaneously, there is a significant reduction in construction schedule due to this technology. There is also lift slab method, MEP unit method, bathroom unit method, prefab piping (PFP) method, and other prefabricated methods that are being used on site in various forms (KICT, 1995). Furthermore, they are increasing the accuracy and mitigating labor shortages by utilizing robots and eliminating labor.

Fifth, for Korean construction projects, a systematic schedule management utilizing a schedule management tool is not employed. Other than a number of special projects that utilizes schedule management professional service very systematically from the initiation of a project to construction completion, such as Primavera[7], not many are known to implement such tools. Most projects use a schedule bar chart for schedule management. This proves that most projects are operated based on experience and systematic schedule management is not employed.

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[7] Premavera is a schedule management software for PC developed in 1983. It is a project management software that utilizes network method based on PERT/CPM that can be used in various projects from planning stage to completion for schedule/performance/resource management.

3.3.3 Ecosystem of the Vicious Cycle and Practice in Korean Projects

In Korea, there are still many projects that have not implemented a systematic project management techniques and management systems. Furthermore, there is very little understanding and research on systematic project management. For the public sector, policies by the government such as “enhancing efficiency of public construction project” are merely suggestions to prevent wasted budget, exceeded project time, and decreased quality. However, when the government changes along with the ministers, it will only take a few years to draft another one of the “enhance efficiency” policies.

For the private sector, it is difficult to analyze the actual numerical figure on project failures as there are no statistical data available. However, both public and private sectors have about the same amount of failed projects. Both sectors have an extremely low awareness of the need for PCA and a systematic method in implementing a project. General understanding by a Korean owner is that design should be carried out by the designer and construction by the constructor who will build according to the drawings. It seems obvious in a sense. However, there is a fundamental issue when the architect is unable to deliver drawings with the high level of completion that will help accomplish the owners goal of ① target cost, ② target schedule, and ③ quality standards. Incomplete drawings that have not gone through the process of proper review, coordination among architecture, structure, electric, etc., or verification of the cost or constructability review are provided to the constructors. Even Korea's leading global companies believe that construction without drawings is fast-track method and rushes construction to decrease construction time. As such, rework due to design changes and increased cost due to over design is a common issue. Such issues would have been prevented if PCA and project management were performed accordingly.

The fundamental cause of these impacts can be said to be lack of professionalism. Designing is a highly skilled and specialized task in a construction project, and should the design be wrong, there could be severe damage when the building or facility is completed. If such a problem does occur, it would become a threat to the public safety and a cause for various safety accidents. For instance, the designer was largely at fault for the collapse of the Sampoong Department Store (Construction Vision Forum, 2006).

Design for the above mentioned department store was possible in Korea as the design companies operating for sales rather than prioritizing design quality. Additionally, policies and regulations were not in implemented to make the designer responsible during that time. Furthermore, these practices were encouraged by the market because the design fee was far below than that of western countries. Designers had to compete for the lowest cost forcing them to decrease their fees to the fullest extent. Most Korean designers outsource the design in several packages once the concept design is complete to some degree. On the other hand, the US and other western countries outsource the MEP and structural work from time to time (there are many large design firms capable of in house design) but all the architectural design work is performed by them. This is because the quality of the design cannot be guaranteed if it is subcontracted. In the US, whether it is a public or private building that has been completed, if an accident occurs due to bad design and design defects are found, the design company will be lawfully responsible. Even if a person falls from the stairs located outside the building and it was determined that the design was at fault, a lawsuit against the design company will ensure. Despite the fact that the US design practices are much more advanced than that of Korea's, 92% of owners responded that the drawings were not suitable for construction (CMAA Owners Survey, 2005).

On the contrary, there were very few cases where the design company was liable for design issues in Korea. As a result, what is supposed to be a specialized field became a low-cost bidding field without quality assurance. The vicious cycle of not reviewing the subcontracted drawings and not performing coordination among the architecture, MEP and structure, resulted to a design drawing that lacks completeness and discrepancy, which is then supplied to the constructor. Hence, there is an increase in project failure and decrease in competitiveness occurs.

In the US, there is a peer review policy for major buildings or facilities where a third party is required to review in order to strictly manage the roles and responsibilities among the stakeholders. Although there is a similar design review policy in Korea, it is not enforced well. Furthermore, as there is a separation of the design and construction in most project delivery methods, best practices are not implemented, such as IPD or partnering (where the constructor participates during the design phase). Considering all the practices comprehensively, Korean design lacks the quality or competitiveness compared to that of western countries. Therefore, Korean design firms have contributed to the decreasing competitiveness of Korea's construction industry

Even when success or failure of a project depends on the competitiveness of the preconstruction phase, construction companies put little effort to improve competitiveness or enhance technology. Instead, they are focused on the quantitative growth which is leading to large scale deficit and bad construction. In order to survive the Korea's low-cost centered market, companies attempt to win an order first and then identify issues with the design drawings in an attempt to regain the deficit through design changes. Another major issue is that there are a number of dishonest methods prevalent in the Korean construction market during project bidding.

The Korea construction industry is failing to break out of the vicious cycle to form a win-win ecosystem and create best value. There are a number of reasons which includes the owner's inability, and the ordering system in Korea, which is far from global standards. Also, professional services such as construction, design engineering and project management, have lost its value and the construction industry is focused more on construction itself.

Not only are the suppliers responsible for polluting the Korean construction ecosystem but so are the government and ordering bodies in the public sector for not improving the irrational policies and practices.

Meanwhile, the UK, the US, and other western countries are extremely good examples. There are 20 strategic practices mentioned in the checklist (Table 3-6) that were derived from the Latham Report from 1994 (a report that began the construction innovation in the UK) and a report by the Construction Industry Board (CIB) titled "Towards a 30% Productivity Improvement in Construction" have significant implications (Kim, 2006). The 20 strategic practices implies that great performance can be achieved by establishing construction strategies and direction, and implementing best practices early in the project, further emphasizing the importance of PCA.

Table 3-6 A Checklist for Construction Productivity Improvement (Sampled Items)

- Change the industry culture
- Ensure design and construction processes work as one
- Foster teamwork and partnership
- Rationalize project structures
- Establish industry standards for information technology
- Make quality the main requirement of all elements of the design and construction process
- Prefabrication and preassembly should be a part of design considerations
- Life cycles, and all-life costs, of buildings and their fittings must be a principal part of design and maintenance considerations
- Quality and value must not be ignored in the pursuit of the lowest price
- Benchmarking must be used to measure improvements of practice and productivity

3.4 Schedule Reduction Measures through PCA

For the success of a project and to achieve the owner's goal, it is necessary to establish an execution plan through PCA, and increase the competitiveness and completeness of the design by providing professional services and selecting a competent team. This section will discuss the measures of reducing schedule through PCA as well as specific details of CSFs for schedule reduction, and suggest schedule reduction methods.

3.4.1 Schedule Reduction and PCA Critical Success Factors (CSFs)

Among the major factors in construction, cost, time, and quality, project duration, or schedule, is the one factor that is differs largely depending on the owner's will and the competency of the execution team. As stated in Section 2.2, there are many examples where schedule was reduced, such as the 20,000m^2 distribution center in 3 months, or the 5 floor apartment in 6 days. Similarly, the ESB example also has an outstanding schedule reduction performance as mentioned before.

Therefore, depending on the owner's will and the execution plan, the construction schedule can vary based on the PCA results. Major issues in reducing schedule PCA through are the following:

(1) Strategy

A clear vision and commitment by the owner's chief executive is required to establish the project's strategic goals, and a project execution plan is needed to drive the project goals. The owner's requirement and design requirement must be very clear, and laws, policies, risks and external factors have to be analyzed in depth and included in the execution plan.

(2) Organization

A competent organization by the owner is needed to execute the project. If necessary, the CM/PM team can be used to represent the owner. Appropriate project stakeholders and experts from various fields should participate. Decision making authority and appropriate roles and responsibility have to be assigned as needed. A committee that involves key decision makers for the project, such as the Policy Committee (Steering Committee), was used for the ESB and should be established, and a practical committee at a project manager level is also necessary.

Best practices, such as partnering or IPD, should be utilized as early as possible and by building trust and active communication with the project stakeholders, the design and construction can be integrated at an early stage of the project. All effort should be put in by the project stakeholders to achieve the project's strategic goals established by the project owner. Finally, the owner must have the philosophy and leadership during the procurement phase in order to select the best and most competent organization, such as the PM, designer, and constructor, to excel during the project.

(3) System

In addition to the strategy and strategic goals, and the organization to execute the project, an execution system is needed. Project execution system includes a process, tools and technique, measurement and evaluation system.

A process needs a strict review system and risk management for each PCA phase, which should include a management process and management points. Since the main tasks of PCA can be said to be the design process, a systematic design management system should be established to check and simulate the cost, schedule and quality throughout the design stages.

For tools and technique, implementing PMIS and BIM tools that are essential for communication between stakeholders is needed, and techniques, such as lean, target cost design and VE can contribute in achieving the project goals by decreasing or streamlining schedule or cost. Furthermore, a dispute resolution procedure and system can be established in order to mitigate and manage disputes that may arise during the project.

In order to evaluate the performance and status the project, management points for every project phase should be monitored. A system should be developed to provide constant feedback on performance that will allow a quick response to issues that may arise once the performance management system is implemented.

As a result, overall activities had been discussed concerning PCA, however, it is not wise to only consider schedule in order to decrease construction time but rather a holistic approach of PCA in which the activities are interconnected is necessary. Schedule reduction depends on the will of the owner and how well the project is prepared during the preconstruction phase. Furthermore, selecting a competent project team in advance and involving them early in the project is essential.

3.4.2 Schedule Reduction Methodology

There are many methods to decrease the overall project time or schedule. However, it is possible to create an outstanding example of schedule reduction by only preparing early in the project. These are the various methodologies in reducing the schedule:

(1) Implementing resources (manpower, equipment)

There is an example of completing a floor of structural work per day by employing the maximum amount of manpower and equipment as was done in the ESB. There are also a number of similar cases. As mentioned in 3.1.1, the tall residential building in New York and the hotel construction implemented a 2-day cycle for the concrete structural work. It is a method planned in advanced by utilizing the maximum amount of manpower to complete concrete structural work floor in two days. Utilizing the necessary resource in order to meet the schedule's target cycle (e.g. 1-day cycle, 2-day cycle) will prove to be successful and eventual decrease the overall schedule. Once the project type and scale is decided, the total amount of manpower utilized for entire construction does not mean as much as the amount of manpower utilized per day. For example, if there is an apartment project that requires 100,000 man-day and an average of 100 people are mobilized, the project will be completed in 1,000 days. If 200 people are mobilized, the project will be finished in 500 days. Of course, such mathematical calculation does not consider all factors and may be unrealistic, but if one should manage all the factors involved well, then the above hypothesis would be valid with very little difference in the total number as long as material and construction equipment is applied in a similar manner. The 1-day cycle of the ESB or the 2-day cycle of the New York residential buildings exploits a similar concept. Other than the construction plans, a prerequisite that will allow such construction methods to happen is the design drawing, with approved techniques, that is outstanding in buildability. Also, supreme management techniques and logistics plan is essential when a large resource is implemented. Nevertheless, the trade-off relationship between resource and cost should also be considered carefully.

Although unrelated to construction, an interesting example would be the demolition of a 500m highway bridge located in China was demolished overnight by utilizing 116 excavators.[8] This implies that by mobilizing more manpower can help achieve drastic schedule reduction.

(2) Schedule reduction based on technology such as pre-fabrication or factory production

3D printing, as mentioned in Section 3-1, was utilized in order to erect a 5 floor apartment in 6 days. Also, a 30 floor hotel construction by BSB (Broad Sustainable Building) was completed in 15 days. Although the construction will require verification, it is definitely one of the many groundbreaking attempts. BSB utilized the factory production method for not only the structure but also for the finishing. Daewoo Engineering & Construction, Korea, developed the DWS method, which was first implemented at the Salt Lake Apartment in Hawaii, to fabricate the PC

[8] Joongang Ilbo (2016.9.8) “116 Excavators demolish a bridge overnight”

wall and floors including all the finishing as a unit at the factory which was transported and then assembled on site. Pre-fabrication, floor by floor method, etc., are commonly used in Japan to drastically decrease the construction schedule. Such construction methods always require pre-engineered plans prior to prefabrication and construction.

(3) Decreasing project time by decreasing design phase utilizing PCA or IPD

By involving a competent construction team (CM/PM can perform construction portion without the construction company during the preconstruction phase) using PCA or IPD, it is possible to make early decisions on design, and also to include systems used by the specialized contractors or MEP companies. As such, it would be possible to decrease the overall project time as shown in Figure 3-5. Also, it would be possible to noticeably decrease project schedule by integrating the design and construction using the fast track method. A representative example of fast track would be the ESB and the World Cup Main Stadium in Korea. By utilizing PCA and IPD or partnering to review the constructability in advance, make decisions on design, and reduce the selection process of suppliers, it is possible to decrease the design phase and procurement phase resulting in a shorter overall project schedule.

As long as the owner’s will is definite and a competent project team can be engaged to support the owner, it is possible to decrease schedule as seen by the ESB example. Although the construction itself is very important, the PreConstruction Activity of pre-planning will assist a project to be a success.

3.5 Summary

This chapter reviewed examples of PCA and schedule reduction, including the ESB example. Based on the in depth study of the ESB example, groundbreaking methods to decrease schedule and critical success factors were analyzed. Then, schedule reduction methods through PCA were discussed. This chapter can be summarized as the following:

(1) The relationship between PCA and schedule reduction was studied through examples in the preliminary studies. Also, the causal relationship between the two was well discussed. Statistically, although schedule reduction and resource cost have a trade-off relationship, it is possible to decrease both schedule and cost where a best practice was introduced.

(2) The success factors of the ESB and best practice were analyzed in depth. The state of when the ESB was constructed and project success factors were analyzed, and the best practices, logistics, and other unique features of the ESB were further analyzed. Then, PCA for the ESB in terms of team design approach, constructor as a CM, prompt decision making and problem solving methods were further reviewed.

(3) Lack of awareness about project schedule management, and the concept of schedule reduction is not properly addressed in Korea, the project schedule will always be longer compared to that of the US or Japan. Although there are many causes that contribute to it, lack of project management and lack of understanding the importance of schedule are the major causes. As a result,

when constructing a building of similar scale, Korea would take 1.5 to 2.5 times longer than the US or Japan. The premodern practices by the designer, constructor, and supplier, and the lack of owner's participation have created a vicious ecosystem in the Korean construction industry. This has led to the weakening of competitiveness and a stumbling block in the industry's development. On the other hand, the UK as well as other western countries have a win-win relationship between the suppliers and owners in which they create the best value for each other, creating a virtuous ecosystem for the construction industry. As a result, constant effort to innovate and improve the industry has taken place. Such innovation is focused on strengthening the activities during the preconstruction phase, which highlights the importance of PCA.

(4) Schedule reduction and PCA CSFs were discussed in terms of strategy, organization and system. Also, essential CSFs during preconstruction phase in order to reduce schedule were discussed. Three methods were discussed for PCA and schedule reduction: ① implementing large amount of resources such as manpower and construction equipment to decrease to construction time; ② utilizing technologies such as pre-fabrication or factory manufacturing to minimize site work and decrease the schedule; and ③ implementing IPD or partnering to PCA, together with fast track to decrease design time as well as the overall construction time.

Chapter 4. Developing PCA Evaluation Form

This chapter extracts the critical success factors that affect the success of a construction project. Through the critical success factors related to PCA, an evaluation form is developed. Then, the developed evaluation form is applied to a real project, and a pilot test is carried out in Chapter 5 to verify that it can be utilized as a systematic verification tool.

As mentioned in the previous chapter, schedule reduction and other factors in executing the construction project are largely affected by the management of PCA. Hence, the PCA evaluation form was developed in order to manage PCA structurally and systematically. The following is the process in developing and verifying the PCA evaluation form. First, the critical success factors of a construction project were extracted utilizing the previous studies. Second, factors that require management during preconstruction phase were extracted. The extracted PCA shaped the evaluation form and the importance value was calculated for each factor. The PCA evaluation form with weighted scores utilized the PDRI (Project Definition Rating Index) scoring in order to develop an evaluation chart, subsequently used to evaluate real projects. The result of the evaluation using the PCA evaluation form was compared with the type of PCA in Chapter 5 to analyze the correlation and verify the adequacy of the PCA evaluation form.

4.1 Analysis of Critical Success Factors (CSFs) and Preconstruction Phase CSFs

4.1.1 Definition of CSFs

The priorities of a construction project are to meet the cost, schedule, and quality goals. During the process of meeting the goals, various factors affect the project and decide its success or failure. Some factors affect the project success more than others are called the critical success factors (CSFs) (Jeon and Kim, 2003). Although the definition of CSFs differs within each literature, the general meaning of CSFs can be summarized as the following:

(1) A few key areas in which performance is essential for the project manager in order to reach the project goals (Rockart, 1982).

(2) Areas that must be managed every day in order for the team to work efficiently and effectively (Rowlinson, 1999).

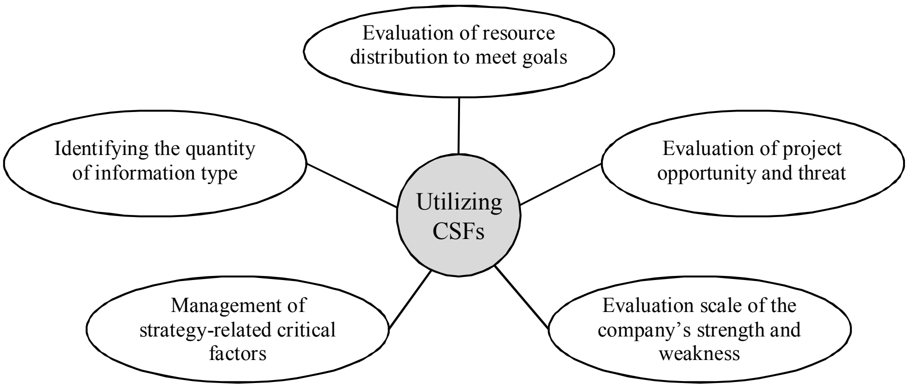


Figure 4-1 Measures to Utilize the Critical Success Factors (Jeon and Kim, 2003)

For the project success, a more detailed management of the CSFs is necessary, and by effectively utilizing it, it is possible to efficiently distribute resources in order to meet the project goal. Furthermore, it is possible to identify the strength and weakness of the company executing the project. Also, it is possible to prioritize the key management points appropriate to the project strategy which can then be used in assessing the opportunity and threat of the project. CSFs can also be used to identify the necessary information and type of data during a project.

4.1.2 Applicable CSFs during the Preconstruction Phase

There is varying research on CSFs of a project. Park and Kim (2003) analyzed previous literature and extracted the success factors for small scale construction projects per construction phase. Based on a 5 point scale and interviews with experts, the importance of each factor was determined and those factors that differed more than 1.5 points from the factual survey were selected to be a CSFs. Since this research differentiated the CSFs for each phase of this research, it was possible to identify which CSFs are applied during the preconstruction phase.

Table 4-1 Success Factor List for Small Scale Construction Project per Phase

Project Stage	Project Success Factors
Planning Stage	The Importance of early design stage, project success and level of early planning, details of early planning, application of owner's desire, number of consultants involved, owners knowledge of the project, documents and standardization of procedures and methods, and regulations on the project scope, risk management approach, sharing resource among projects and the procurement plan
Design Stage	The Importance of team meetings, application of the owner's desire, participation of the head of construction, measurement of design appropriateness, constructability evaluation, consideration of safety management, consideration of quality and maintenance management, amount of design change and effect on project, time spent on design review, and evaluation form or degree of management
Construction Stage	The Importance of Material/equipment procurement for project success, the need for material/equipment vendor selection during the procurement phase, review of appropriateness of equipment plan, evaluation form and degree of management during material/equipment procurement, incentives for workers, existence of quality management team, evaluation form to enhance quality, the need for a construction manual, meetings amongst the owner, designer, and constructor, degree of safety management, usage of safety management fee, safety education when hiring or changing jobs, communication between owner and designer, constructability evaluation, evaluation form or degree of management, competence evaluation of the leader, selecting appropriate manpower fit for project characteristic, degree of communication within company, relationship with subcontractors, and evaluation form for manpower and organization management

Chua et al., (1999) derived CSFs from performance goals such as schedule, cost, and quality which are 1) project characteristic, 2) contract conditions, 3) project participants, and 4) process (both ways). Then analytic hierarchy process (AHP) method was utilized to identify how much CSFs affect schedule, cost, and quality, and based on the results, a CSF list was created.

Since the characteristics of CSFs are management criteria during a project, this research suggests CSFs that can be utilized before construction. It is possible to develop an evaluation form, measure, and evaluate with the extracted CSFs.

Table 4-2 CSF List per Type

Type	Project Success Factors
Project Characteristic	Political risk, economic risk, effect on the public, authority on technique approval, appropriateness of funding, site location, constructability, authority, project scale
Contract Conditions	Realistic obligation, distinctive goal, identification and distribution of risk, appropriateness of planning and specifications, formal dispute resolution process, motivation and incentive
Project Participant	PM skills, PM authority, PM dedication and participation, owner's skill, owner's team skill, turnover rate of owner's team, management support of the owner, owner's project record, degree of owner service, constructor's core manpower skills, constructor team's skill, turnover rate of constructor's team, management support of the constructor, constructor's project record, degree of constructor's service, CM's core manpower skills, CM team's skill, turnover rate of CM's team, management support of the CM, CM's project record, degree of CM's service, sub constructor's core manpower skills, sub constructor team's skill, turnover rate of sub constructor's team, management support of the sub constructor, sub constructor's project record, degree of sub constructor's service, supplier's core manpower skills, supplier team's skill, turnover rate of supplier's team, management support of the supplier, supplier's project record, degree of supplier's service
Process (Both ways)	Official design communication, unofficial design communication, official construction communication, unofficial construction communication, function plan, design completion at the beginning of construction phase, constructability program, level of module, level of automation, need for skilled workers, report update, cost update, schedule update, design adjustment meeting, construction adjustment meeting, site supervisor, roles and responsibility chart, common goal, motivation factor, and relationship

Lyer and Jha (2006) extracted 55 project success factors in terms of the project schedule based on previous literature. After the survey, Kaiser criterion of factor extraction was utilized to extract the final CSFs.

The CSFs are categorized as project manager's skill, owner and chief executive's support, monitoring, feedback and adjustment, friendly work environment, project participants' dedication, and owner's capability.

Table 4-3 CFSs that Affect Project Schedule

Type	Project Success Factors
Project Manager's Skill	PM skill in adjusting the constructor, PM leadership, PM skill in adjusting the owner, decision making authority of the PM team on site, periodical cost update, PM technical skills, authority of the PM in selecting core team and financial decision making, construction adjustment meeting, usability of the planned cost, equipment, material and other resource, authority distribution to other teammates by the PM, technical education on human resource, understanding responsibility by various project participants, PM skill in adjusting the team members and sub-contractors, effective monitoring and feedback by PM, sustaining unofficial communication channel between project teams, and dedication by all project participants
Owner and Chief Executive's Support	Understanding the difficulties in the owner's operation and appropriate decision making, selecting an experienced PM at the early phase of a project, project support by the chief executives and establishing core task, active support by the chief executives for the PM and team members, maintaining unofficial communication channel between project teams, construction adjustment meetings, and usability of the planned cost, equipment, material and other resources
Monitoring, Feedback and Adjustment	Effective monitoring and feedback, positive attitude of the PM and project participants, PM skill in directing the chief executives, Effective monitoring and feedback by the PM, understanding the responsibilities of various project participants, PM skill in directing team members and subcontractors, active support by the chief executives for the PM and team members
Friendly Work Environment	Establishing definite work scope and condition during bidding phase, sympathetic social environment, sympathetic environment on site, monitoring and feedback for the owner, sympathetic political and economic environment
Project Participant's Dedication	Project dedication by all participants, delegation of authority by the chief executives to PM, ability of delegating authority to team members by PM
Owner's Capability	Timely decision making by the owner or the owner's engineer, monitoring and feedback by the owner, and technical education for human resource

Based on Table 4-4, the relationship between CFSs and schedule and customer satisfaction was analyzed. While all performance evaluation parameters have an effect on the overall project, there are specific parameters that affect schedule, cost, quality, and customer satisfaction. This can be an important reference when extracting PCA for construction schedule and customer satisfaction during the preconstruction phase (Iyer and Jha, 2006).

Table 4-4 Relationship between Performance Evaluation Parameters and CFS

Factor number	Factor names	Factor identification number after pooling	Factor numbers as obtained after factor analysis in respective performance criteria			
			Schedule	Cost	Quality	No-dispute
	Success Factors					
1	Project manager's competence	F_1	Factor 1	Factor 1 Factor 3	Factor 1	Factor 1
2	Top management support	F_2	Factor 2	Factor 2	Factor 2 Factor 3	Factor 2
3	Monitoring and feedback	F_3	Factor 3	Factor 4	Factor 6	
4	Favorable working conditions	F_4	Factor 4	Factor 7		Factor 4
5	Commitment of all project participants	F_5	Factor 5	Factor 6		
6	Owner's competence	F_6	Factor 6	Factor 7	Factor 5	Factor 3
7	Interaction between project participants – internal	F_7			Factor 4	
8	Interaction between project participants – external	F_8			Factor 7	
9	Good coordination among project participants	F_9	Factor 3	Factor 5		
10	Availability of trained resources	F_{10}				Factor 5
11	Regular budget update	F_{11}				Factor 6
	Failure factors					
12	Conflict among project participants	F_{12}	Factor 1	Factor 1	Factor 1 Factor 6	Factor 1
13	Project manager's ignorance and lack of knowledge	F_{13}	Factor 2	Factor 2	Factor 3	Factor 2
14	Hostile socioeconomic environment	F_{14}	Factor 3	Factor 4	Factor 2	Factor 3
15	Owner's incompetence	F_{15}	Factor 4			
16	Indecisiveness of project participants	F_{16}	Factor 5	Factor 5		Factor 4
17	Harsh climatic condition at site	F_{17}	Factor 6	Factor 4	Factor 2	Factor 6
18	Aggressive competition during tender stage	F_{18}	Factor 7	Factor 6	Factor 7	
19	Negative attitude of project participants	F_{19}				Factor 4
20	Faulty project conceptualization	F_{20}		Factor 7	Factor 4	Factor 5

4.1.3 Framework for PCA Project Evaluation Model

Kim et al., (2016) developed a CSF Matrix (Figure 4-2) that included ① project phase, ② CSFs type and ③ project characteristics (contract type, owner type, project type etc.) as the three axis in the cube. The CSFs, which is based on Iyer and Jha (2006), can be used for management during each project phase.

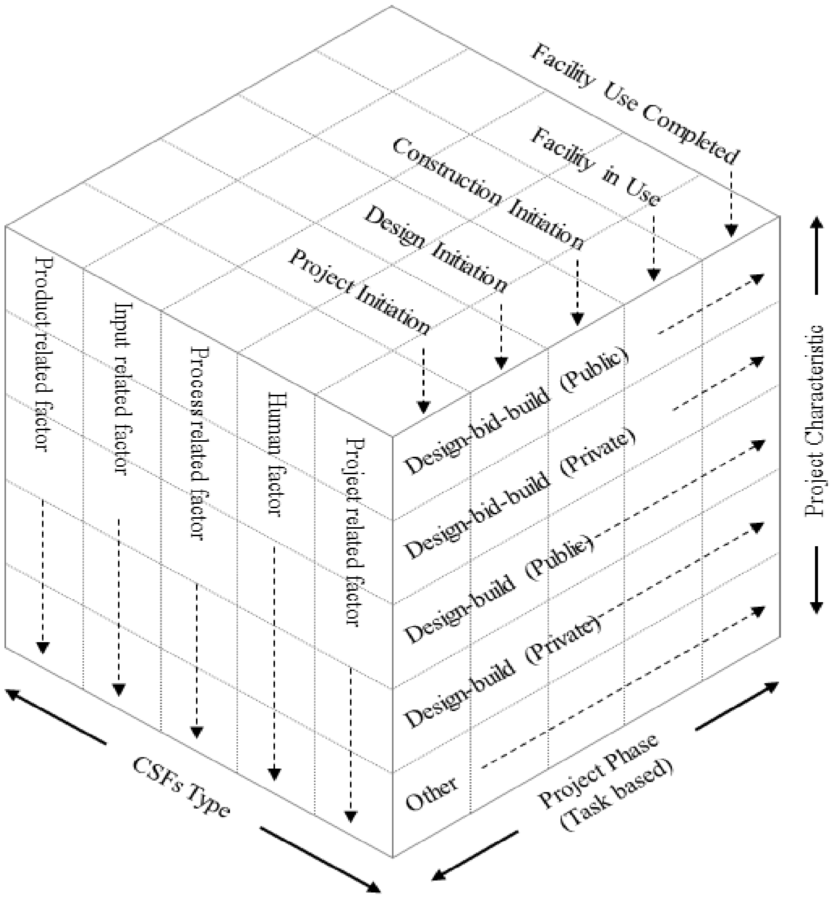


Figure 4-2 Critical Success Factor Cube

This can become a framework for analyzing the relationship between CSFs and the performance evaluation parameters (cost, schedule quality, customer satisfaction, etc.) based on the project stage, type of CSFs, and project type (contract type, owner type, project type etc.). Iyer and Jha (2006) attempted to find a correlation between the CSFs and performance evaluation parameters by utilizing a survey (5-point or 7-point scale) to identify the CSFs achievement score. Then the score and the performance evaluation parameter (schedule) were analyzed using multiple regression analysis to quantify the relationship. Wang, Gibson and Huang (2008) utilized the PDRI method to score CSFs and compared it with project cost performance utilizing multiple regression analysis and the ANN algorithm. This research utilizes the CSFs type and project types from the critical success factor cube. Project initiation and design initiation were selected as management criteria for the preconstruction phase.

During the preconstruction phase, CSFs exists in various forms ranging from project phase, type, and effects. Among the categories, expert opinions are needed in order to identify which factors have the most effect.

4.2 Developing CSFs Based PCA Evaluation form

4.2.1 Extracting CSFs applicable for Preconstruction Phase

This research utilized the method of extracting the CSFs from Kim et al., (2016). First, factors that affect the project success were extracted from previous studies. Factors with common characteristics were grouped to form a total pool of 122 CSFs.

After, a questionnaire survey was conducted to extract a total of 139 CSFs. Through focus group interviews (FGI), the 139 CSFs were filtered to 45 CSFs by deleting duplicate and unnecessary factors. Finally, after another round of FGI, 9 major CSFs and 27 sub-CSFs were extracted.

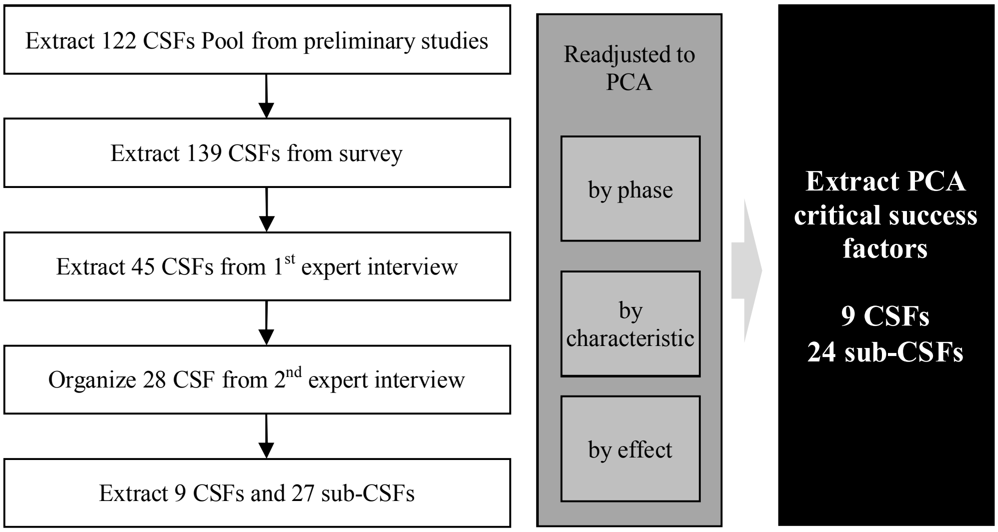


Figure 4-3 Process of Extracting CSFs (Kim et al., 2016) (partially edited)

CSFs from previous research were generally for standard projects. This research utilizes the extracted CSFs from previous research on the preconstruction phase. As such, the CSFs were reorganized based on phase, characteristics, and effect, and resulted with 9 major CSFs and 24 sub-CSFs. Each CSFs and Sub-CSFs are included in Appendix 1.

Table 4-5 CSFs for PCA

PCA CSFs : Critical Success Factors	
Sub-CSF : Sub Critical Success Factors	
Strategy	**CSF 1. Setting Goals: Establish goals based on project objectives and directivity**
	CSF 1-1. Owner's definite vision and goals (Business Objectives)
	CSF 1-2. Establish feasible project objectives & top management's commitment
	CSF 2. Establish Execution Plan: Establish a realistic and achievable execution plan
	CSF 2-1. Establish definite owner's requirement and design requirement
	CSF 2-2. Establish systematic project execution plan
	CSF 3. External environment analysis: Active measures on external factors that affect the project
	CSF 3-1. Analyze internal & external economic/social/political environment and other various risks
	CSF 3-2. Review applicability of related policies or laws
Organization	**CSF 4. Organizational Structure: Establish a systematic and efficient organizational structure**
	CSF 4-1. Establish a competent owner's organization(team)
	CSF 4-2. Select competent project stakeholders and utilize experts in various sectors
	CSF 4-3. Establish procedures and R&R for all stakeholders
	CSF 5. Capability of project stakeholders: Acquiring stakeholders capable of maximizing skills in the right time
	CSF 5-1. Project manager's leadership and skills
	CSF 5-2. Architect's capability in design and project execution
	CSF 6. Team Building(team work): Establishing trust through definite communication between participants
	CSF 6-1. Establish trust between project participants and active communication
	CSF 6-2. Early integration of design and construction (IPD)
	CSF 6-3. Active integration of partnering
	CSF 6-4. Establish communication strategy and system for each participants
System	**CSF 7. Process: Enhancing interrelationship between construction life-cycle**
	CSF 7-1. Risk management by identifying and eliminating risks per project phase
	CSF 7-2. Establish management point and management process per project phase
	CSF 7-3. Establish design management system
	CSF 7-4. Establish dispute resolution procedure (contract/dispute/claim management)
	CSF 8. Tool & Technique: Utilizing superior tools and techniques for smooth performance
	CSF 8-1. Implement cost and schedule management tool for each phase
	CSF 8-2. Implement PMIS and BIM tool
	CSF 9. Measurement & Evaluation: Continuous feedback on performance through measurement and evaluation
	CSF 9-1. Periodic monitoring of management points per project phase
	CSF 9-2. Establish review system for each PCA phase
	CSF 9-3. Constant measurement and evaluation of performance by implementation of project performance management system

4.2.2 Determining Weight for Extracted CSFs

The CSFs extracted for this research do not have identical weighting. In order to evaluate the weighting for each factor, 20 construction management experts with an average experience of 27.8 years were surveyed to weigh each CSFs.

Table 4-6 Weight of CSFs for PCA

Critical Success Factors	Weighted Score
CSF 1. Setting Goals: Establish goals based on project objectives and directivity	10
CSF 1-1. Owner's definite vision and goals (Business Objectives)	(4)
CSF 1-2. Establish feasible project objectives & top management's commitment	(6)
CSF 2. Establish Execution Plan: Establish a realistic and achievable execution plan	11
CSF 2-1. Establish definite owner's requirement and design requirement	(6)
CSF 2-2. Establish systematic project execution plan	(5)
CSF 3. External environment analysis: Active measures on external factors that affect the project	5
CSF 3-1. Analyze internal & external economic/social/political environment and other various risks	(2)
CSF 3-2. Review applicability of related policies or laws	(3)
CSF 4. Organizational Structure: Establish a systematic and efficient organizational structure	18
CSF 4-1. Establish a competent owner's organization(team)	(8)
CSF 4-2. Select competent project stakeholders and utilize experts in various sectors	(5)
CSF 4-3. Establish procedures and R&R for all stakeholders	(5)
CSF 5. Capability of project stakeholders: Acquiring stakeholders capable of maximizing skills in the right time	10
CSF 5-1. Project manager's leadership and skills	(5)
CSF 5-2. Architect's capability in design and project execution	(5)
CSF 6. Team Building(team work): Establishing trust through definite communication between participants	13
CSF 6-1. Establish trust between project participants and active communication	(3)
CSF 6-2. Early integration of design and construction (IPD)	(5)
CSF 6-3. Active integration of partnering	(3)
CSF 6-4. Establish communication strategy and system for each participants	(2)
CSF 7. Process: Enhancing interrelationship between construction life-cycle	11
CSF 7-1. Risk management by identifying and eliminating risks per project phase	(20
CSF 7-2. Establish management point and management process per project phase	(2)
CSF 7-3. Establish design management system	(5)
CSF 7-4. Establish dispute resolution procedure (contract/dispute/claim management)	(2)
CSF 8. Tool & Technique: Utilizing superior tools and techniques for smooth performance	7
CSF 8-1. Implement cost and schedule management tool for each phase	(5)
CSF 8-2. Implement PMIS and BIM tool	(2)
CSF 9. Measurement & Evaluation: Continuous feedback on performance through measurement and evaluation	15
CSF 9-1. Periodic monitoring of management points per project phase	(5)
CSF 9-2. Establish review system for each PCA phase	(5)
CSF 9-3. Constant measurement and evaluation of performance by implementation of project performance management system	(5)

Each section was based on the 7-point Likert scale, which was converted to 100 point scale to calculate the weighting. Based on the weighted score, the organizational structure section had the highest importance. This signifies that during the preconstruction phase, organizational composition, project stakeholders, and team building to encourage communication is important. Furthermore, other opinions on how to perform CSFs for PCA based on the survey results can be summarized as the following

Table 4-7 Responses by Survey Participants on PCA Evaluation form

#	Contents
1	· Draft and periodically update the owner's requirement with the owner · Decide on professional consulting tasks when design contracting and apply consulting cost · Estimate cost for each design phase and apply to construction bidding · Agree to a fair cost on design change and lead the designer in accomplishing the task
2	· Analyze laws, the surrounding condition, and owner's requirement, including available data in order to identify the exact issue and determine a solution
3	· Create a data for expert consulting category based on project phase and share with sites
4	· Develop a standardized roles and responsibility chart to manage performance and preconstruction CM activity
5	· Understand the difference in project nature due to scale and characteristic · Consider appropriate process rather than complicated and theoretical process
6	· Design review (VE, including specialized consulting) for each design phase · Benchmark similar projects (defect prevention, maintenance management)
7	· Large changes in design occurs due to lack of communication between the designer and client, despite their skills · Check design for mismatch prior to developing working design
8	· Implement a meeting between the chief executive and CMr bi-monthly or periodically for project briefing · Benchmark and apply projects with similar target requested by chief executives · Implement chief executive review system for project decision making · CM participates and reviews the procurement for each sector · Implement BIM from early project stage until project completion · Objective logic and execution is important in persuading a non-expert owner

4.3 Project Evaluation Utilizing PCA Evaluation form

4.3.1 Developing Project Evaluation Form using PDRI Form

Extracted CSFs are the priority in management when performing PCA. The systematic management of the CSFs is requisite in the success of a project. In order to do so, the PDRI form (Appendix 2) was utilized to create a project evaluation form that will evaluate the success of a project.

The PDRI is a tool used during the planning stage of a project in order to enhance the project performance (cost, schedule, management). Not only is it possible to determine how well the project is defined during the project planning phase but also, it is possible to predict how well the project will perform based on the scores. CII carried out extensive research for multiple years on PDRI and developed a PDRI that can be applied to plant & industrial projects, and commercial projects.

This research utilizes the measurement and evaluation method used in PDRI. However, the PDRI Elements had been modified to the CSFs extracted in this research. It is possible to compare the final evaluation value to the expected value of the CSFs in order to determine the successfulness of the project. This research utilizes the PDRI form in order to evaluate the project success at the end of a project (Refer to form in Appendix 2).

4.3.2 Developing PCA Evaluation Form

The PDRI evaluation form was utilized to develop the project evaluation form that compares the initial value of CSFs that were set before the project with the evaluation result after the project is complete in order to determine or estimate the success of the project.

The project evaluation form is composed of 3 sections (establishing definite strategy to achieve project goal; enhancing teamwork through effective and skilled manpower; and systematic and scientific system) that form the CSFs for PCA.

The strategy section involves setting goals, establishing an execution plan and analyzing the external environment. This is to set a goal and to develop a plan to execute it. Analysis of the external environment is to identify the possible risks despite how well the project is managed. The organization section is to create a condition for an effective organizational structure and to identify the capabilities of the project stakeholders. The system section involves procedures and tools. Continuous feedback through measurement and evaluation is an essential category for project management.

CSFs are evaluated from a scale of 0 to 5. If a category is not managed, 0 points are allocated. The scores are recorded in Excel which is weighted automatically within the cell. The cells (results) are added up to reflect the total score and to evaluate the level of PCA for the project.

This rather simple method makes it is possible to identify the categories that have higher weights and provides a more in-depth analysis of the project.

CSFs Evaluation Form

CSF (Critical Success Factors) / Sub-CSF	0	1	2	3	4	5	Score
SECTION Ⅰ – STRATEGY : Establishing definite strategy to achieve project goal							
CSF (Critical Success Factors)	CSF Evaluation Scale						Score
Sub-CSF	0	1	2	3	4	5	
CSF 1. Setting Goals: Establish goals based on project objectives and directivity							
CSF 1-1. Owner's definite vision and goals (Business Objectives)							0
CSF 1-2. Establish feasible project objectives & top management's commitment							0
[Total]							**0**
CSF 2. Establish Execution Plan: Establish a realistic and achievable execution plan							
CSF 2-1. Establish definite owner's requirement and design requirement							0
CSF 2-2. Establish systematic project execution plan							0
[Total]							**0**
CSF 3. External environment analysis: Active measures on external factors that affect the project							
CSF 3-1. Analyze internal & external economic/social/political environment and other various risks							0
CSF 3-2. Review applicability of related policies or laws							0
[Total]							**0**
SECTION Ⅱ – ORGANIZATION : Enhancing Teamwork through effective and skilled workers							
CSF (Critical Success Factors)	CSF Evaluation Scale						Score
Sub-CSF	0	1	2	3	4	5	
CSF 4. Organizational Structure: Establish a systematic and efficient organizational structure							
CSF 4-1. Establish a competent owner's organization(team)							0
CSF 4-2. Select competent project stakeholders and utilize experts in various sectors							0
CSF 4-3. Establish procedures and R&R for all stakeholders							0
[Total]							**0**
CSF 5. Capability of project stakeholders: Acquiring stakeholders capable of maximizing skills in the right time							
CSF 5-1. Project manager's leadership and skills							0
CSF 5-2. Architect's capability in design and project execution							0
[Total]							**0**
CSF 6. Team Building(team work): Establishing trust through definite communication between participants							
CSF 6-1. Establish trust between project participants and active communication							0
CSF 6-2. Early integration of design and construction (IPD)							0
CSF 6-3. Active integration of partnering							0
CSF 6-4. Establish communication strategy and system for each participants							0
[Total]							**0**
SECTION Ⅲ – SYSTEM : Systematic and Scientific System							
CSF (Critical Success Factors)	CSF Evaluation Scale						Score
Sub-CSF	0	1	2	3	4	5	
CSF 7. Process: Enhancing interrelationship between construction life-cycle							
CSF 7-1. Risk management by identifying and eliminating risks per project phase							0
CSF 7-2. Establish management point and management process per project phase							0
CSF 7-3. Establish design management system							0
CSF 7-4. Establish dispute resolution procedure (contract/dispute/claim management)							0
[Total]							**0**
CSF 8. Tool & Technique: Utilizing superior tools and techniques for smooth performance							
CSF 8-1. Implement cost and schedule management tool for each phase							0
CSF 8-2. Implement PMIS and BIM tool							0
[Total]							**0**
CSF 9. Measurement & Evaluation: Continuous feedback on performance through measurement and evaluation							
CSF 9-1. Periodic monitoring of management points per project phase							0
CSF 9-2. Establish review system for each PCA phase							0
CSF 9-3. Constant measurement and evaluation of performance by implementation of project performance management system							0
[Total]							**0**
[T o t a l]							**0**

Figure 4-4 PDRI Evaluation Form used in PCA Evaluation form

4.4 Summary

This chapter developed PCA evaluation form and quantified the performance of PCA for completed projects utilizing the developed evaluation form. Also, its relationship was analyzed comparing the duration of PCA and whether or not it was performed.

(1) The most important critical success factors in performing PCA were divided into strategy, organization and system section on the PCA evaluation form. Each section included 3 CSFs and a total of 24 Sub-CSFs. It is possible to review the project during the preconstruction phase based on each CSF. The evaluation form was developed based on the PDRI form by CII in order to evaluate the success of the project.

(2) The objective of the PCA evaluation form is to assess and quantify how well the PCA is performed, and provide information to the owners and managers (PMr, CMr) in order to establish measures based on the evaluation results. Hence it would be possible to increase PCA performance, and increase the possibility of project success by improving the implementation of PCA if PCA are believed to be lacking

(3) The PCA evaluation tool will be utilized in Chapter 5 for managers of the 21 projects that have performed PCA. The goal of evaluating the survey is to verify the feasibility of the developed PCA evaluation form. By analyzing the correlation between PCA evaluation scores and PCA duration as well as NPS, this research will attempt to verify the validity of the PCA evaluation form.

Chapter 5. Effect of PCA on Schedule Reduction, Customer Satisfaction, and NPS

This chapter attempts to verify through real cases how schedule reduction, as well as customer satisfaction has an effect on the Net Promoter Score (NPS). PreConstruction Activities (PCA) that were discussed from Chapter 1 – Chapter 4 will be redefined in this chapter, and PCA evaluation form that was discussed in Chapter 4 will be utilized in real projects and the evaluation form score and NPS will be compared. Based on the comparison between the evaluation form score and NPS, the validity of the PCA evaluation form will be verified. Chapter 5 will be composed of research process and analytical results. For research process, a systematic verification of PCA is introduced and the characteristics of the analysis data and research method are discussed. The analysis results are based on the quantitative values of the effect of PCA on schedule reduction. Then, the achievement of customer satisfaction due to proper achievement of PCA is quantitatively and qualitatively analyzed. Afterwards, how a customer that is satisfied has an effect on NPS is verified.

5.1 Research Process and Analysis Method

5.1.1 Definition of PCA in Chapter 5

A significantly higher possibility of project success is possible when there is a common consensus that the key to project success lies in the early stages of a project. The success factor of the ESB was due to owner's leadership, competent designer, and the constructor who took responsibility as a project manager, who all formed a team to perform proper PCA at the early stages of that project. This research defines PreConstruction Activities (PCA) as the activities prior to construction in order to accomplish the initial goals of the project from the owner's perspective. Of the 5 stages in the construction lifecycle, pre-design, design, and procurement stages are considered as the preconstruction phase. It is a critical phase which can create value for project success, and both the preconstruction phase and PCA have a substantial impact on project performance such as quality, cost, schedule, and safety. Design management (DM) is a key activity in PCA and has an important role in project success. The scope of DM includes design review as well as management of cost, schedule, quality, and safety. Among which, project duration or schedule, may differ largely depending on the owner's will and the competency of the project team. Schedule reduction depends on the owner's will, as well as how well the project was prepared during preconstruction phase. It is also imperative to select a competent project team in advance and have the team involved early during the design stage.

This chapter analyzes customer survey data collected for the past 8 years by a leading CM company in Korea to examine the PCA performance from the perspective of the owner. This research utilizes the performance of the CM team from the perspective of the owner and does not include the investor or the user. Depending on the project, the CM team was implemented either during the early design stage, middle of design stage, or end of the design stage. Also, the scope of work for CM depended on when CM was contracted and how much CM manpower was utilized. Hence the scope may include all design management (DM) tasks inclusive of cost, quality, schedule, safety management and so forth, and in some cases the will of the owner may exclude cost management from the scope. As such, DM tasks were selectively included in the scope of work for each construction project. This research verifies that the schedule can be decreased significantly during the early stages of a project subject to the owner's will and the competency of the project manager. Also, this research proves that through successful PCA, a customer that is satisfied can become a loyal customer. Verification that there is a large correlation between input and output in construction, the cycle of PCA → competitive design → high quality and competitive construction → project success → customer satisfaction → customer loyalty (NPS) is also shown.

5.1.2 Research Process

This section attempts to prove that PCA can achieve customer satisfaction and eventually have a positive effect on customer loyalty. Hence, PCA performance is divided into quantitative and qualitative performance. Schedule, cost, quality, safety, etc., are all factors for project success; however, this research focuses on the schedule factor in order to verify the quantitative performance of PCA. For qualitative analysis, how well the customer's needs have been met during the process of a project is analyzed in terms for process satisfaction. This research verifies whether customer satisfaction was achieved through performance satisfaction and process satisfaction of NPS, and also whether customer satisfaction had an effect on the customer loyalty index, NPS. The research process can be represented as Figure 5-1.

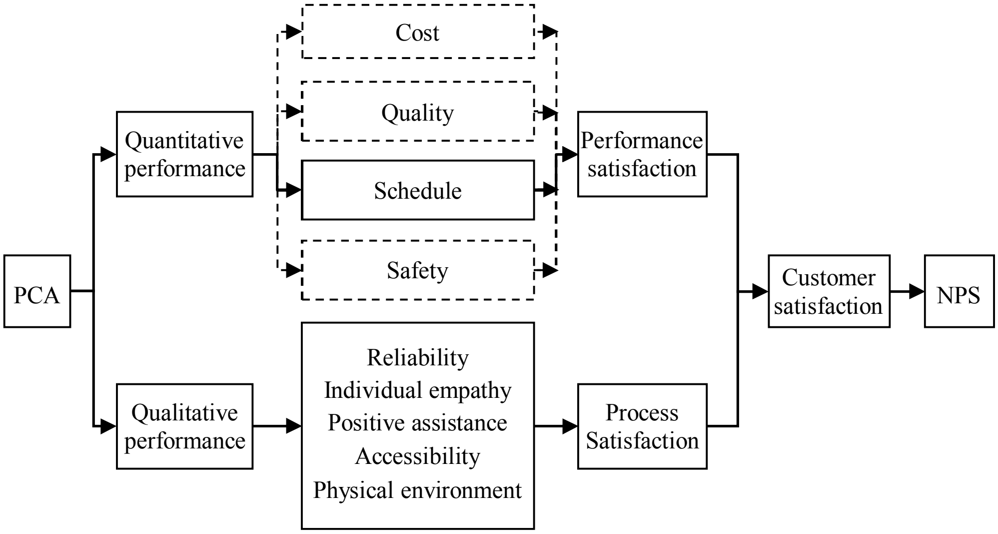


Figure 5-1 Research Process

5.1.3 Analysis Method

(1) Research Subject

These office buildings are mixed-use buildings and have similar characteristics and various floor heights ranging from low-rise to high-rise. Buildings that were completed in Korea between 2007 and 2015 were utilized for this research.

(2) Data Gathering

Project information and customer satisfaction survey results were provided by the H-company, a leading CM company in Korea. There were a total of 65 projects (Appendix 3) utilized for this research and a total of 93 customers responded to the customer satisfaction survey. The reason for higher customer number than projects is due to the fact that the number of project owners differed depending on the project scale, and therefore, there were between 1 and 3 project key staffs from the owner's organization that responded for the survey for a single project. Only customers who have satisfied certain criteria were surveyed and the target customers were the executives (site leader, PM, etc.,) of the owner's organization who have experienced CM and are capable of evaluating the performance of CM. H-company reviewed the owner's rank, period of CM experience, etc., independently to determine the compatibility of the owner in responding to the survey. Since 2007, H-company executed the customer satisfaction survey twice a year, and every year, approximate 100~150 projects were surveyed. Among projects with similar characteristics, office buildings and mixed-use buildings identified extracted for this research. In order to increase the reliability of the customer satisfaction survey results, H-company requested a professional company to execute the survey. For example, the customer list was provided only to the commissioned company and H-company did not participate or manage any of the process afterwards. The investigator of the professional company had a face-to-face interview (Appendix 4) after making appointments with the customers. The interview took approximately 20~30 minutes and all information provided was kept secret. In general, it takes about 2~3 years for a project to be completed. Therefore, customer satisfaction survey is performed multiple times during the project lifecycle. This research utilized survey results that portrayed the overall opinion on the project performance for projects that had been completed. Also, only surveys that were carried out within 6 months after project completion were selected. Another reason on selecting only customer satisfaction results performed after the completion of a project is because a more reliable result was expected after the CM organization had left the project and is away from the owner's organization. The characteristics of the sampled projects can be seen in Table 5-1.

Table 5-1 Sample Characteristics

Number of Floors		Total Project (number of respondents)	Projects without PCA (number of respondents)	Projects with PCA (number of respondents)
Super tall	More than 50	12(14)	4(5)	8(9)
Tall	30~49	5(8)	4(7)	1(1)
Medium	11~29	25(41)	6(10)	19(31)
Low	Less than 10	23(30)	2(3)	21(27)
Total		65(93)	16(25)	49(68)

(3) Concept of Assessment Factors

1) Assessment Factors for PCA

The quantitative effect of schedule reduction is analyzed in order to verify the performance of PCA. Factors such as whether PCA has been performed, the ratio of preconstruction, and ratio of manpower during preconstruction phase are then introduced. The ratio of preconstruction represents the ratio between the involvement of CM during the preconstruction phase to the total duration of CM. Ratio of manpower during preconstruction phase represents the amount of CM manpower involved during the preconstruction phase compared to the total amount of CM manpower for the project. Construction rate per floor and construction period were utilized for schedule. Construction time per floor defines the time (calendar day) required to complete a single floor. Construction period is the time since the beginning of construction to its completion measured in months. The definition of ratio of preconstruction, preconstruction manpower ratio, construction rate per floor, and construction period are defined in Table 5-2.

Table 5-2 Concept and Definition of PCA Assessment Factors

Category	Definition
Ratio of preconstruction	The ratio between the period of time CM was active during the preconstruction phase to the sum of CM activity period during both preconstruction and construction phase
Preconstruction manpower ratio	Amount of CM manpower involved during preconstruction phase to the total amount of CM manpower involved for both preconstruction and construction phase.
Construction rate per floor	Time to construct a single floor (calendar days)
Construction period	Time from beginning of construction to completion (months)

Note : depending on the contract with the owner, CM may be implemented late in the preconstruction phase or may not even be implemented. The supplier has no influence on when it should be implemented.

The equation for the ratio of preconstruction (3), preconstruction manpower ratio (4), and construction rate per floor (5) are shown below.

1) Preconstruction (A) = Duration of CM during preconstruction (months)
2) Total CM Duration (B) = Preconstruction (A) + Construction (months)
3) Ratio of Preconstruction $= \frac{A}{B} * 100(\%)$
4) Preconstruction manpower ratio (%)
   CM Manpower during Preconstruction phase/ Total CM Duration (B)
5) $Construction\ Rate\ per\ Floor = \frac{Total\ Construction\ Period}{Total\ Floors}(Calendar\ days)$

2) Evaluating Customer Satisfaction

This research utilized the KS-SQI model in order to evaluate customer satisfaction. KS-SQI (Korean Standard-Service Quality Index) was a product of a joint research between by joint Management Lab in Seoul National University and Korea Standard Association (KSA) to evaluate the service quality based on customers who have experienced the product or service of a company. KS-SQI model is separated into performance satisfaction and process satisfaction. Performance satisfaction is composed of service performances which are the primary needs fulfillment and unexpected benefits. Process satisfaction concerns the experience a customer has during the service which are reliability, individual empathy, positive assistance, accessibility, and physical environment. This research adapted the categories in KS-SQI that is more appropriate to the CM characteristic. A total of 19 criteria were assessed on a 9-point scale (1-absolutely not; 9-extremely agree). Whether the core service, CM, achieved project goal achievement, project performance, and customer-centric process were included for the three categories in the performance satisfaction region. The two additional services were differentiated service and additional service not within the contract scope. Reliability for process satisfaction concerns the necessary skills and knowledge in performing a service. It includes the staff's knowledge and skill, abidance to the service contract, and transparent project management. Individual empathy includes explanation understandable by the customer, service attitude, and consideration of the customer. Positive assistance concerns the will to provide a speedy service to the customer's needs, and includes prompt response, voluntary customer service, adequate explanation of the project progress, and responding to customer dissatisfaction. Accessibility concerns the convenience of the service provided in terms of time and location, which is the ability to contact the CM team online or offline. Finally, the physical environment is to evaluate the service, which involves the office environment, and external appearance of the staff

Table 5-3 Evaluation Categories for Customer Satisfaction Factors

SECTION Ⅰ - Performance Satisfaction		
Primary Needs Fulfillment: Fulfilling the primary needs of the customer through the service		
X1 X2 X3	Achieved project goal achievement Project performance Customer-centric process	Baccarini (1999)
Unexpected benefits: Providing unexpected benefits to the customer differentiated from other companies		
X4 X5	Differentiated service Additional services not within the Contract scope	Parasuraman (1985)

SECTION Ⅱ - Process Satisfaction		
Reliability: Acquiring necessary technology and skills to perform service		
X6 X7 X8	Staff's knowledge and skills Abidance to the service contract Transparent project management	Maloney (2002)
Individual Empathy: Customer reception attitude		
X9 X10 X11	Explanation understandable by the customer Service attitude Consideration of the customer	Grönroos (1984)
Positive Assistance: The will to provide a speedy service to the customer's needs		
X12 X13 X14 X15	Prompt response Voluntary customer service Adequate explanation of the project progress Responding to customer dissatisfaction	Tang et al. (2003) O'connor and Yang (2004) Oliver and DeSarbo (1988)
Accessibility: Convenience of the service provided in terms of time and location		
X16 X17	Contact staff offline Contact staff online	Parasuraman (1985)
Physical environment: Physical environment to evaluate the service		
X18 X19	External appearance of the staff Office environment	Brady and Cronin (2001)

Note: The 7 constructs of performance satisfaction and process satisfaction were adopted from the Korean Standard Association (KSA). KSA and H-Company adjusted the 7 constructs appropriate for the characteristic of CM based on previous research. The survey sample utilized in this research is shown in Appendix 3.

3) Evaluating NPS (Net Promoter Score)

Net Promoter Score, NPS, is an index, developed by Reichheld from Bain & Company, a US consulting company, which determines the amount of loyal customers a company has. This research utilizes the NPS evaluation methodology Reichheld published in the Harvard Business Review. The single question of "how much are you willing to refer the services by H-Company to friends and family?" was utilized. Customers were able to choose from an 11-point Likert scale from 0 to

10. Points ranging 0 to 6 were detractors, 7 to 8 were passively satisfied customers, and 9 to 10 points were promoters. According to the NPS methodology, among the responses by the customers, NPS is calculated by subtracting the detractors from the promoters (NPS = Promoter % - Detractor %) as suggested in Figure 2-9 and Table 2-4. Passively satisfied customers are not included in the NPS calculation.

(4) Calculation Method for Each Assessment Factor

Analysis method utilized in this research is shown in Table 5-4. Statistic method was applied depending on the relationship between the dependent and independent variables appropriate for the research objective. SPSS 21 was utilized in order to analyze the data.

Table 5-4 Analysis Method based on Evaluation Factor

Evaluation Factor	Content	Analysis method	Dependent variable	Independent variable
Schedule reduction	Difference analysis of construction rate per floor based on with or without PCA	t-test	-	-
	Trend analysis of construction rate per floor based on with or without PCA	Linear regression analysis Quadratic regression analysis Exponential regression analysis	Construction rate per floor	Total floor (super+base floor)
	Relationship between manpower and construction rate per floor during preconstruction phase	Linear regression analysis	Construction rate per floor	Ratio of manpower utilized during preconstruction phase
	Relationship between construction period and PCA	Multiple Regression analysis	Construction time	Super, base floor, total area
Customer Satisfaction	Difference between customer satisfaction based on with or without PCA	ANOVA	Process satisfaction Performance satisfaction	2 Categories – performance satisfaction 5 categories – progress satisfaction
	Relationship between process satisfaction, performance satisfaction, and referral intention	Correlation analysis	-	-
	Difference between referral intention and 5 constructs of process satisfaction	ANOVA	5 constructs of process satisfaction	Referral intention
NPS	Difference analysis on NPS	NPS methodology ANOVA	NPS	PCA Process satisfaction Performance satisfaction

5.2 Verification of PCA Evaluation Form

5.2.1 Survey based on the Evaluation Form

In order to verify the PCA evaluation form suggested in Chapter 4, 21 of the 65 projects that were analyzed in Chapter 5 were utilized. The evaluation form was utilized to assess the performance of a project by the responsible construction manager (Table 5-5).

Table 5-5 Evaluation Result using PCA Evaluation form

Number	Project type	Evaluation form Score	PCA Duration (%)
1	Office	99.6	33.0
2	Office	92.4	21.4
3	Office	92.0	0.0
4	Office	87.6	43.4
5	Office	86.6	31.4
6	Complex facility	86.4	0.0
7	Mixed-use facility	86.2	14.8
8	Office	82.4	18.2
9	Office	81.8	27.3
10	Office	81.6	36.0
11	Office	80.8	30.4
12	Office	75.4	38.9
13	Mixed-use facility	75.2	6.6
14	Office	73.2	14.6
15	Office	71.4	25.0
16	Office	70.4	6.3
17	Office	64.8	0.0
18	Office	62.0	0.0
19	Office	60.6	27.3
20	Office	59.6	0.0
21	Office	50.8	20.5

PCA Duration : The ratio between the period of time CM was active during the preconstruction phase to the sum of CM activity period during both preconstruction and construction phase

5.2.2 Verification of the PCA Evaluation Form Results

The result of the PCA evaluation form was utilized to identify the correlation between the PCA evaluation score and NPS, and PCA duration, as it was the most appropriate method that can verify the applicability of the PCA evaluation form.

1) Relationship between PCA Evaluation Form Score and NPS

To analyze the correlation between the evaluation score due to PCA and NPS, PCA evaluation score was divided into excellent (more than 80), good (70~80), and insufficient (less than 70). Among the 65 projects where NPS was applied, PCA evaluation was utilized for 21 projects. Based on the PCA evaluation scores, NPS was calculated. Projects with above excellent (more than 80) PCA evaluation scores had an average NPS of 63.6, which is 23.6 points higher than projects with insufficient (less than 70) PCA evaluation scores that averaged an NPS of 40.0 (Table 5-6). Also, higher PCA evaluation scores due to PCA resulted in higher in all sections (strategic planning, establishing organization, system operation).

Table 5-6 PCA Evaluation Form Score and NPS

Evaluation form Score		Strategic planning	Establishing organization	System operation	Sum	NPS
Excellent	More than 80	22.8	37.6	26.6	87.0	63.6
Good	70~80	20.0	31.6	21.4	73.1	60.0
Insufficient	Less than 70	15.3	24.7	19.6	59.1	40.0

2) Relationship between PCA Evaluation Form Score and PCA Duration

Comparing the PCA evaluation score and the duration of PCA can become an index that can systematically evaluate how well PCA was performed. PCA duration was analyzed based on the PCA evaluation score. For projects with PCA evaluation score of more than 80 points had an average PCA duration of 22.3%, PCA evaluation score between 70-80 points had an average of 18.3%, and less than 70 points had an average of 9.5% (Table 5-7). It is possible to conclude that based on the results, there is a correlation between the PCA evaluation score and PCA duration.

Table 5-7 PCA Evaluation form Score and Ratio of Average PCA Duration

Evaluation form Score		Number of Case	Ratio of Average PCA Duration
Excellent	More than 80	11	22.3 %
Good	70~80	5	18.3 %
Insufficient	Less than 70	5	9.5 %
Total		21	18.8 %

In order to further analyze the relationship between the PCA evaluation score category and PCA duration, PCA duration was separated in to more than 30%, 10~30%, and less than 10%. The analysis results showed that for projects with excellent (more than 80) PCA evaluation score, majority (45.5%) of the projects had more than 30% of PCA duration. On the other hand, for projects with insufficient (less than 70) PCA evaluation score, there were no projects that had more than 30% of PCA duration while less than 10% of PCA duration accounted for more than 60% of the projects (Table 5-8).

Table 5-8 PCA Evaluation form Score and PCA Duration

Evaluation form Score		n	More than 30%		10~30%		Less than 10%	
			n	%	n	%	n	%
Excellent	More than 80	11	5	45.5	4	36.4	2	18.1
Good	70~80	5	1	20.0	2	40.0	2	40.0
Insufficient	Less than 70	5	-	0.0	2	40.0	3	60.0

PCA Duration : The ratio between the period of time CM was active during the preconstruction phase to the sum of CM activity period during both preconstruction and construction phase

In conclusion, to verify the validity of the PCA evaluation form, PCA evaluation score and NPS, and PCA evaluation score and PCA duration were compared. It was possible to derive the conclusion that to achieve high NPS with PCA, the total PCA duration should account for more than 30% of the total contracted schedule. Although the number of projects utilized for both methods is not sufficient to show statistical significance, PCA evaluation results and actual data that were utilized did show correlation, which was meaningful for this research.

5.3 Effects of PCA on Schedule Reduction

This section compares the construction rate per floor with construction period based on whether PCA was performed or not. Then, the effect of PCA on schedule reduction is confirmed. First, based on an appropriate model that can explain the relationship between number of super floors and construction rate per floor, the effect of PCA on schedule reduction is confirmed. Then, construction rate per floor and construction period was compared with whether PCA was performed or not, duration of PCA, and manpower used for PCA. By comparing, it was possible to verify the effect of PCA on schedule reduction.

5.3.1 Effects of PCA on Construction Rate per Floor

1) Correlation between Total Floor (Super + Base) and Construction Rate per Floor

The scatter plot of total floors and construction rate per floor was analyzed to determine the relationship between total floors and construction rate per floor. The results showed that the higher a building is, the shorter construction rate per floor is

(Figure 5-2). The correlation analysis result between total floors and construction rate per floor showed that there was a negative correlation (-0.683**). This shows that there is a correlation where taller a building is, the shorter the construction rate per floor becomes. In other words, a lot of time is spent at the lower levels setting up for the structural work which is why lower buildings have a longer construction rate per floor. However, when a building is taller, there are more standard floors which require repetitive structural, finishing and other work. As such, the construction rate per floor decreases due to learned skills. Hence, higher a building is, more standard floor exists which results in shorter construction rate per floor.

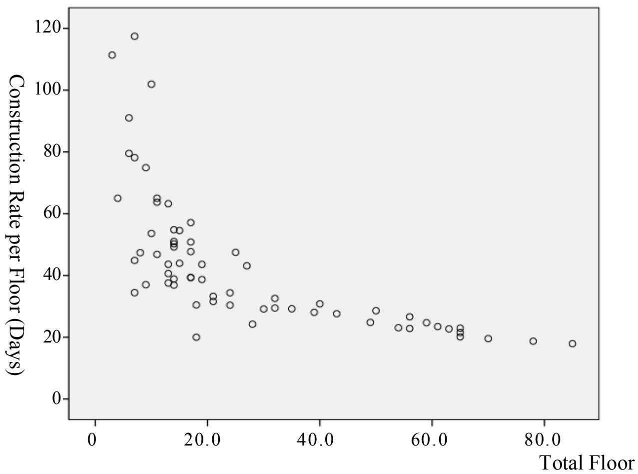


Figure 5-2 Scatter Plot of Total Floor and Construction Rate per Floor

2) Developing Total Floor (Super + Base) and Construction Rate per Floor Relationship Model

The relationship between total floors and construction rate per floor will be studied utilizing regression analysis. Linear, quadratic, and exponential regression analysis was utilized in order to identify a model that can explain the relationship between total floors and construction rate per floor as accurate as possible.

Regression equations based on the three models were extracted and the equation that is most applicable was selected and utilized in analyzing the relationship between PCA and schedule reduction.

① Regression Analysis for Total Floor (Super + Base) and Construction Rate per Floor

Total floors were inputted as the independent variable, and construction rate per floor was the dependent variable for the linear regression analysis. Total floors had a negative (-) effect on the construction rate per floor. Hence, as total floors increased, construction rate per floor decreased. Based on the linear regression analysis, the scatter plot for the total floor and construction rate per floor is shown in Figure 5-3.

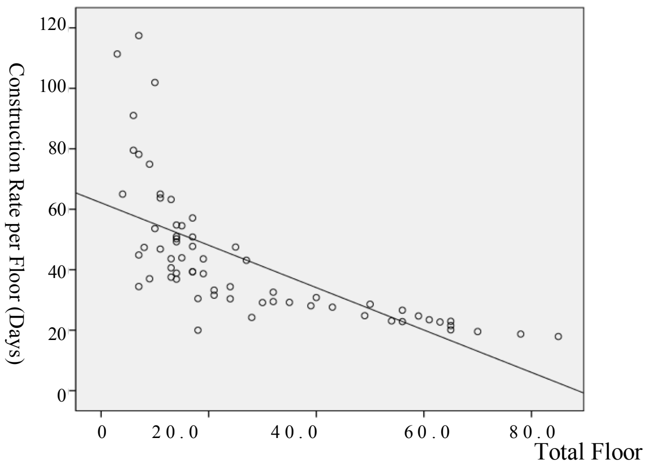


Figure 5-3 Linear Regression Model for Total Floor and Construction Rate per Floor

F value for the regression model ranged from ρ=.000 to 51.839, and t value was -7.200 (P=.000), which is statistically significant. Regression equation had R^2=.451, an explanation power of 45.1% (Table 5-9). Hence, the independent variable (total floor) can explain 45.1% of the dependent variable (total construction rate per floor).

Table 5-9 Linear Regression Analysis Results for Total Floors and Construction Rate per Floor

Independent variables	Dependent variables	SE	*b*	t-value	Significance	Statistics
Total Floor (super+base)	Constant	3.321	62.110	18.701	.000	$R = .672$, $R^2 = .451$ Adjusted $R^2 = .443$ $F = 51.839$, $p = .000$
	Construction rate per floor	.097	-.701	-7.200	.000**	

** Significant at p-value < 0.01

Regression equation based on the linear regression analysis results for total floors and construction rate per floor is shown in Equation 5-1.

$$y = 62.110 - 0.701x \qquad (5-1)$$

② Quadratic Regression Analysis for Total Floor (Super + Base) and Construction Rate per Floor

It is possible to observe that the scatter plot in Figure 5-2 for total floors and construction rate per floor is not a linear relationship in which the increase of total floors yielding to decrease of construction rate per floor, but rather a non-linear relationship. To derive a regression equation that can explain a non-linear relationship, quadratic regression analysis was utilized. Quadratic regression equation had R^2=.572, an explanation power of 57.2% which is 12.1% higher than the linear regression (45.1%). Based on the quadratic regression analysis, the scatter plot of total floor and construction rate per floor is shown in Figure 5-4.

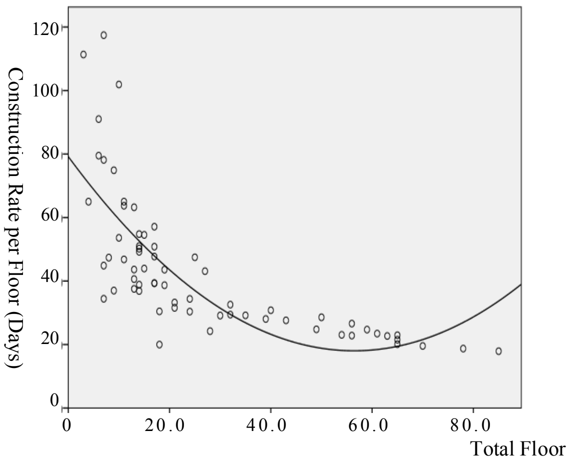


Figure 5-4 Quadratic Regression Model for Total Floor and Construction Rate per Floor

F value for the regression model ranged from ρ=.000 to 41.461, and t value was -6.003 (P=.000), which is statistically significant (Table 5-10)

Table 5-10 Quadratic Regression Analysis Results for Total Floor and Construction Rate per Floor

Independent variables	Dependent variables	SE	*b*	t-value	Significance	Statistics
Total Floor (super+base)	Constant	5.042	79.198	15.707	.000	R = .756, R^2=.572 Adjusted R^2=.558 F=41.461, p=.000
	Construction Rate per floor x	.361	-2.167	-6.003	.000**	
	Construction Rate per floor x^2	.005	.019	4.184	.000**	

** Significant at p-value < 0.01

Regression equation based on the quadratic regression analysis for total floors and construction rate per floor is shown in Equation 5-2.

$$y = 79.198 - 2.167x + 0.019x^2 \quad (5\text{-}2)$$

③ Exponential Regression Analysis for Total Floor (Super + Base) and Construction Rate per Floor

As shown in Figure 5-2 scatter plot, construction rate per floor decreases drastically as the total floor increases. Exponential function is more suitable in explaining such effect, and therefore, exponential regression analysis was utilized. The scatter plot for total floor and construction rate per floor is shown in Figure 5-5.

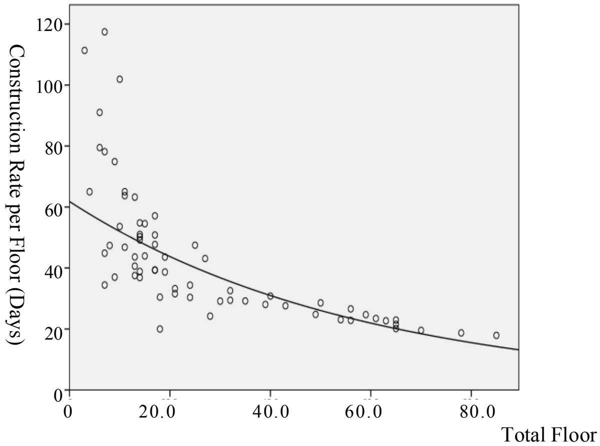


Figure 5-5 Exponential Regression Model for Total Floor and Construction Rate per Floor

Exponential regression equation had R^2=.644, an explanation power of 64.4% which is 7.2% higher than the quadratic regression (57.2%) and 19.3% higher than the linear regression (45.1%) (Table 5-11). It was possible to increase the explanation power by 19.3% by simply adjusting the regression analysis and without additional independent variables. Such effect shows that the exponential model is very useful in analyzing the relationship between total floors and construction rate per floor.

Table 5-11 Exponential Regression Analysis Result for Total Floors and Construction Rate per Floor

Independent variables	Dependent variables	SE	*b*	t-value	Significance	Statistics
Total Floor (super+base)	Constant	3.409	61.802	18.130	.000	R = .803, R^2=.644 Adjusted R^2=.639 F=114.089, p=.000
	Construction Rate per Floor	.002	-.017	-10.681	.000**	

** Significant at p-value < 0.01

The regression equation based on the exponential regression analysis is shown is Equation 5-3.

$$y = 61.802 * e^{-0.017x} \tag{5-3}$$

Table 5-12 shows the regression analysis between total floors and construction rate per floor based on linear, quadratic, and exponential regression equations. By observing the R2 value, which is the capability of the independent variable (total floors) explaining the dependent variable (construction rate per floor), linear regression was 45.1% (R2 = 0.45), quadratic regression was 57.2% (R2 = 0.572), and exponential regression was 64.4% (R2 = 0.644). Among which, the highest regression model that explained the relationship between total floor and construction rate per floor was the exponential model (R2 = 64.4%).

Table 5-12 Comparison of Total Floors and Construction Rate per Floor Regression Model

	R^2	F-value/p	t-value/p	Model Equation
Linear	0.451	51.839/.000**	-7.200/.000**	$y = 62.110 - 0.701x$
Quadratic	0.572	41.461/.000**	-6.003/.000**	$y = 79.198 - 2.167x + 0.019x^2$
Exponential	0.644	114.089/.000**	-10.681/.000**	$y = 61.802 * e^{-0.017x}$

3) Relationship between Preconstruction period and Construction Rate per Floor

In order to verify the relationship between PCA and construction rate per floor, we first need to determine whether the amount of time invested during preconstruction phase has an effect on construction rate per floor. Therefore, a regression analysis is utilized to describe the non-linear relationship between total floor (super + base floor) and the construction rate per floor. Exponential regression analysis was used due to its high power of explanation (R^2). R^2 derived from regression analysis represents how well the regression line describes the actual model. Although the power of explanation (R^2) for the linear regression analysis between PCA and construction rate per floor is 46.6%, the exponential regression analysis had a R^2 of 64.5%, which is 19.3% higher than linear regression. Hence, 64.4% of the dependent variable, construction rate per floor (y) is described by the information of the independent variable, total floor (x) based on the exponential regression analysis. As a result, the relationship between the independent variable, total floor, and dependent variable, construction rate per floor, is described well. Exponential regression analysis was used to determine the relationship between construction rate per floor and projects with over and less than 30% of preconstruction period. First, the result of the exponential regression analysis for projects with more than 30% of preconstruction was: estimate b = -0.023 and R^2 = 0.762; a high explanation value of 76.2%. This means that 76.2% of the dependent variable, construction rate per floor (y) can be explained by the independent variable, total floor (x). For projects less than 30% of preconstruction phase, the results were b = -0.015 and R^2 = 0.611; also high explanation value of 61.1% as shown in Table 5-13.

Table 5-13 Regression Analysis Result for Time Invested on Preconstruction Phase (%)

	Model Summary					**Estimate**	
	R^2	**F**	**df1**	**df2**	**Significance**	**Constant**	***b***
30% or more	.762	48.057	1	15	.000**	77.944	-.023
30% or less	.611	72.370	1	46	.000**	55.601	-.015

** Significant at p-value < 0.01

The equation for the exponential regression model for projects with more than 30% of preconstruction phase can be expressed as shown in Equation 5-4, and for projects with less than 30% of preconstruction phase can be expressed as shown in Equation 5-5. When interpreting the regression equation, the significance of the statistical value of the regression slope needs to be verified. The regression slope between projects with more than 30% of preconstruction phase was $e^{-0.023x}$ and for projects with less than 30% of preconstruction phase was $e^{-0.015x}$ which are considered quite significant. When the regression slope has a negative sign, it represents that when the independent value, total floors, increase, the dependent value, construction rate per floor, decreases. In addition, when analyzing the regression slope for projects with more than 10% of preconstruction phase and projects with more than 20% of preconstruction phase, the results were $e^{-0.018x}$ which is a lower value than that of a project with more than 30% of preconstruction phase. As such, it can be said that for projects with more than 30% of preconstruction phase have a high effect on schedule reduction.

$$y = 101.939 * e^{-0.023x} \tag{5-4}$$
$$y = 71.449 * e^{-0.015x} \tag{5-5}$$

The exponential regression equation for both projects with more than and less than 30% of preconstruction were compared as shown in Figure 5-6. As shown in the graph, projects with more than 30% of preconstruction phase have more effect on schedule reduction than that of projects with less than 30% of preconstruction phase. As a result, the more preconstruction phase is, less construction rate per floor was seen in taller buildings than shorter buildings, which is why the regression slope has that form. In other words, it is more advantageous to perform PCA from the early stage of preconstruction phase for high rise buildings than shorter buildings. Especially for high rise buildings, by implementing a superb organization from the early stages of preconstruction to control, and manage the major management points and milestones for the project will have a large impact in decreasing the construction schedule.

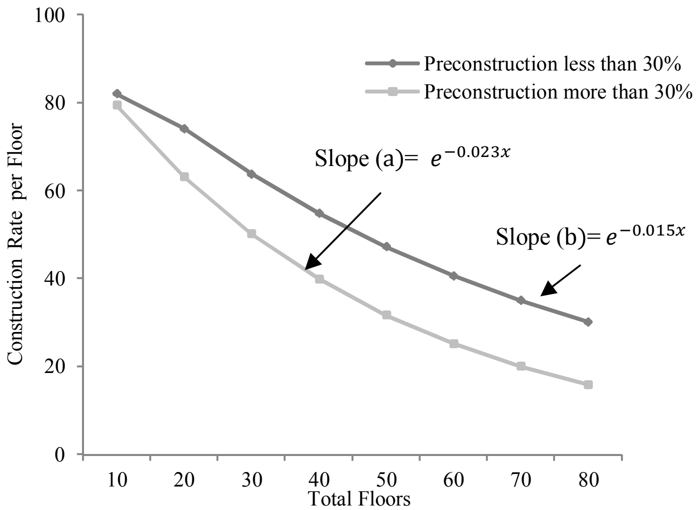


Figure 5-6 Regression Slope for Ratio of Preconstruction Phase and Construction Rate per Floor

Equation 5-6 describes the change in the dependent value when the independent value increases by 1 in the exponential model (Allison, 2003).

$$100(e^{b}) - 1 = 100(Exp(b) - 1) \tag{5-6}$$
$$100(e^{-0.023}) - 1 = 100(0.977 - 1) = -2.3\% \tag{5-7}$$
$$100(e^{-0.015}) - 1 = 100(0.981 - 1) = -1.5\% \tag{5-8}$$

It is possible to determine the change in construction rate per floor when the total number of floors increases by a single floor by inputting the value into the exponential regression model. By applying it to Equation 5-6 for projects with more than 30% of preconstruction, the changes in the construction rate per floor was -2.3% as seen in Equation 5-7. Similarly, when a single floor increases for projects with less than 30% of preconstruction, the change in the construction rate per floor was -1.5% (Equation 5-8). Therefore, it is possible to determine that the changes in the construction rate per floor for projects with more than 30% of preconstruction was 0.8% higher than that of the project with less than 30% of preconstruction phase. This represents that by performing more PCA (constructability review, supporting decision making, selecting project participants, etc.,) at the early stages of preconstruction phase will help decrease the overall construction period.

4) PCA and Construction Rate per Floor

Construction rate per floor was compared for projects with and without PCA to determine if PCA has an effect on schedule reduction. Total floor (super + base floor) was divided into 3 sections: 1-20 floors, 20-40 floors, and 40 or more floors. T-test was utilized in order to verify the average difference between the two groups. For projects with more than 40 floors, construction rate per floor showed a significant value. Without performing PCA on projects with over 40 floors, the construction rate per floor was 24.8 days, and performing PCA was 21.3 days (Table 5-14). Hence, when the total floor exceeds 40 floors, the difference in construction rate per floor for projects with and without PCA was 3.5 days. However, when the total floor was below 20 floors, and between 20-40 floors, it did not show any statistical significance. As such, it is possible to conclude that PCA is effective for projects that exceed 40 total floors, which would be high rise or super tall building projects. The reason why there were no significant differences between

PCA projects with was less than 20 or between 20~40 total floors is because low buildings have a relatively shorter schedule than tall or super tall buildings. Also, there are relatively much less standard floors in lower buildings which is why the effect of schedule reduction is not seen as much. Furthermore, since 20-40 floor buildings have longer construction rate per floor than buildings with 40 or more floors, although the difference of construction rate per floor for projects with PCA and without PCA for buildings over 40 floors is 3.5 days, it is not considered statistically significant.

Table 5-14 Difference of Construction Time per Floor based on PCA

Total floor (super+base)	Mean		Std. Deviation		T value	P value
	Without Preconstruction	With Preconstruction	Without Preconstruction	With Preconstruction		
Above 40	24.865	21.373	3.3024	1.9850	2.523	.025*
20~40	35.581	32.035	10.6489	5.7846	.723	.485
Below 20	53.624	55.601	32.5395	19.7042	-.210	.835

* represents significance under 0.05

5) Relationship between Manpower Utilized during Preconstruction Phase and Construction Rate per Floor

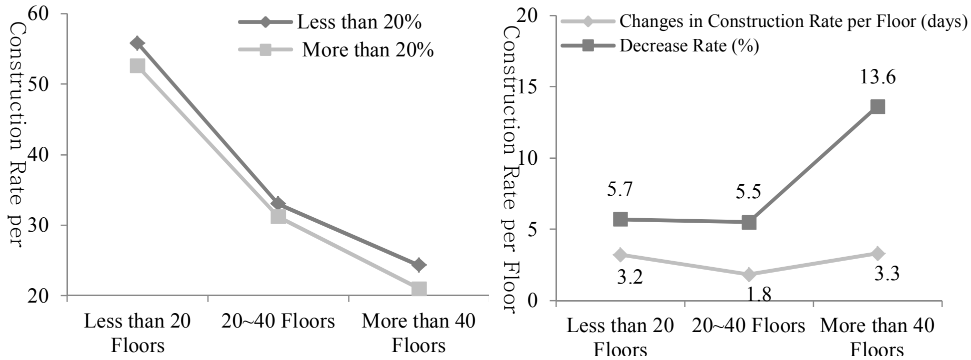
Even if the PCA period is long, there may be inefficient amount of manpower implemented. Likewise, when PCA period is short, there may be too many manpower involved during preconstruction phase. In this research, the relationship between ratio of manpower involved during preconstruction and construction rate per floor is also analyzed in addition to preconstruction period. Again, total floor was divided into 3 sections: 1-20 floors, 20-40 floors, and 40 or more floors, and manpower utilized during preconstruction phase was divided into more than 20% and less than 20%. Based on the analysis result, for projects with more than 40 floors and with more than 20% of manpower utilized during preconstruction phase had a construction rate per floor of 21.0 days. On the other hand, projects with less than 20% of manpower utilized during preconstruction phase had a construction rate per floor of 24.3 days, with a difference of 3.3 days. The 3.3 days difference in construction rate per floor was a 13.6% decrease from the construction rate per floor for projects with less than 20% of manpower utilized during preconstruction phase. Similarly, after analyzing the construction rate per floor for projects with more than 20% of manpower and less than 20% of manpower during preconstruction phase, for projects between 20 to 40 floors had a 5.5% decrease in the construction rate per floor. For projects with less than 20%, a 5.7% decrease was seen (Table 5-15).

Table 5-15 Difference of Construction Time per Floor based on Manpower Invested during Preconstruction Phase

Total Floor (super+base)	Less than 20% manpower during preconstruction phase (A)	More than 20% manpower during preconstruction phase (B)	Difference (C)	Decrease rate for construction rate per floor C/A*100
More than 40 floors	24.3 days	21.0 days	3.3 days	13.6%
20~40 floors	33.0 days	31.2 days	1.8 days	5.5%
Less than 20 floors	55.8 days	52.6 days	3.2 days	5.7%

The relationship between manpower utilized during preconstruction phase and construction rate per floor is shown in Figure 5-7 (a). Since construction rate per floor decreases as the building is taller, the decrease rate of the construction rate per floor may be the same, but there is more of a decrease effect for taller buildings than shorter buildings for the construction rate per floor. In Figure 5-7 (b), the decrease rate for construction rate per floor on less than 20% of manpower and more than 20% of manpower during preconstruction phase was 5.7% for 20 floors or below, 5.5%

for 20~40 floors, and 13.6% for 40 or more floors. There was a large difference for tall buildings compared to short buildings. Tall buildings have a relatively complex schedule and a longer construction period compared to short buildings. It can be assumed that the construction period was reduced due to comprehensive review on civil, structure, architectural, electrical, mechanical, and other sectors during the preconstruction phase for tall buildings.



(a) Manpower for PCA and Construction Rate per Floor

(b) Manpower for PCA and changes in Construction Rate per Floor

Note (a) More than 20% of manpower during preconstruction phase vs. less than 20% construction rate per floor (days)
(b) More than 20% of manpower during preconstruction phase vs less than 20% construction rate per floor (days) and reduction rate for construction rate per floor (%)

Figure 5-7 Difference of Construction Time per Floor based on Manpower Invested during Preconstruction Phase

Regression analysis was utilized to analyze the relationship between manpower implemented during preconstruction phase and construction rate per floor. Dependent variable was the construction rate per floor for all floors, and independent variable was the manpower utilized during preconstruction phase. Analysis results showed that when the independent variable, manpower utilized for preconstruction phase, increased by 5% (5%, 10%, 15%), the construction rate per floor decreased by 0.438, 0.577, 0.618 days when the total floor increased by 1 floor (Table 5-16). Therefore, the more manpower is utilized during preconstruction phase, the more schedule reduction was possible. As such, the performance of PCA does not only depend on the duration of PCA, but also depends on the selection of an excellent team that will perform PCA in an effective manner. To find out when construction rate per floor is decreased the most due to manpower during preconstruction phase, regression analysis was utilized by increasing the manpower ratio by 20%. When total floors increased by 1 floor, the construction rate per floor decreased by 0.578 days, which is similar to that of when the manpower ratio is 10% during preconstruction phase. Therefore, when the manpower ratio is 15% during preconstruction is when the construction rate per floor is the most optimal. Such results show that it is not possible to decrease construction rate per floor by simply utilizing more manpower, and that manpower that is appropriate to the project characteristic must be utilized.

Table 5-16 Difference of Construction Time per Floor based on Manpower Invested during Preconstruction Phase

Ratio of manpower during preconstruction phase	SE	*b*	t-value	P value	Statistics
More than 20%	.205	**-.578**	-2.824	.014*	R = .602, R^2=.363 Adjusted R^2=.317 F=7.975, p=.014
More than 15%	.175	**-.618**	-3.537	.002**	R = .611, R^2=.373 Adjusted R^2=.344 F=12.512, p=.002
More than 10%	.209	**-.577**	-2.757	.009*	R = .413, R^2=.170 Adjusted R^2=.148 F=7.601, p=.009
More than 5%	.184	**-.438**	-2.382	.022*	R = .335, R2 =.112 Adjusted R2 =.092 F=5.674, p=.022

* .p < 0.05, **. p < 0.01

5.3.2 Effects of PCA on Construction Time

Correlation analysis was utilized.in order to determine the correlation between super, base, and total area with the construction period. The results proved that there was a high correlation between all the factors. Especially, super floor (0.889**) had the highest correlation with the construction period (Table 5-17).

Table 5-17 Correlation Between Super Floors, Base Floors, Total Area, and Construction Time

	Unit	Average	Standard Deviation	Inter-Construct Correlations			
				1	2	3	4
1. Super Floor	Floor	23.215	20.2380	1			
2. Base Floor	Floor	3.677	2.0395	.411**	1		
3. Area	M^2	137359.753	186802.5950	.738**	.209	1	
4. Construction period	Month	28.482	12.1013	.889**	.500**	.703**	1

** Correlation is significant on both sides with value less than on 0.01

Scatter plot was analyzed to determine the relationship between super floors and construction period which had the highest correlation. As number of super floors increased, the construction period also increased linearly (Figure 5-8).

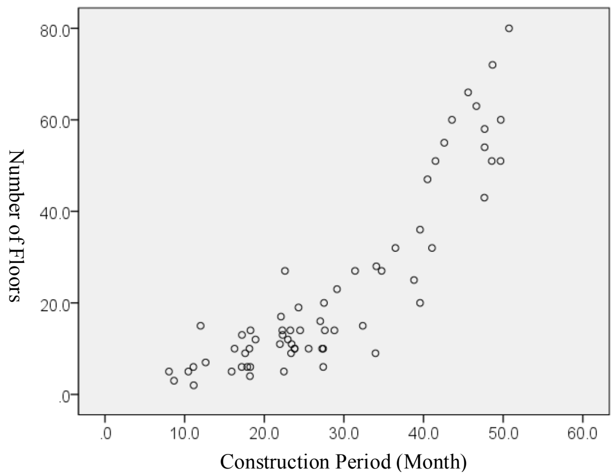


Figure 5-8 Scatter Plot of Super Floor and Construction Time

Ratio of preconstruction period was divided into less than 10%, more than 10%, more than 20%, and more than 30%, to determine how PCA affects the construction period. Construction period was the dependent variable whereas the number of super floors, number of base floors, and total area (unit: 330m^2 per floor) was utilizing for the multiple regression analysis. Based on the multiple regression analysis (Equation 5-9), the regression analysis result of the ratio of preconstruction period are shown in Equation 5-9 to 5-13.

Multiple regression analysis: $y = a + b1x1 + b2x2 + b3x3 \ldots bnxn$ (5-9)
More than 30%: $y = 10.982 + 0.422x1 + 0.954x2 + 0.161x3$ (5-10)
More than 20%: $y = 11.396 + 0.439x1 + 0.746x2 + 0.185x3$ (5-11)
More than 10%: $y = 10.460 + 0.442x1 + 1.124x2 + 0.180x3$ (5-12)
Less than 10%: $y = 12.470 + 0.473x1 + 1.173x2 + 0.127x3$ (5-13)

For example, the result of the model summary for when preconstruction phase is more than 10% in Table 5-18 has a very high correlation (R) of 0.926 between the independent and dependent variable. R^2 was also a high value of 0.857, where the independent variable (super, base, and total area) is capable of explaining the dependent variable (construction time). F value, which determines the validity of the regression line, was p=.000 that is less than 0.05 proving the regression line to be valid. Also, the Durbin-Watson, which detects the correlation in the residuals, shows that the regression model is not valid as the value is closer to 0 or 4. However, Durbin-Watson was 1.684 which is closer to 2 and not close to 0 or 4, which states that the residuals have no correlation and the regression model is valid. The equation for when the ratio of preconstruction phase is more than 10% is shown in Equation 5-12 and can be interpreted as the following.

If other independent variables have similar condition, then

- When super floor increases by 1 floor, construction period increases by 0.442 months,
- When base floor increases by 1 floor, construction period increases by 1.124 months,
- When total area (unit: $330m^2$ per floor) increases by a unit, construction period increases by 0.127 months.

Table 5-18 Regression Analysis of Time Invested on Preconstruction Phase and Construction Time

Ratio of preconstruction phase	**Independent variable**	***b***	***β***	**t-value**	**Significance**	**Tolerance**
More than 30%	Constant	10.982		5.315	.000**	
	Super	.422	.744	7.154	.000**	.711
	Base	.954	.185	1.780	.099	.712
	Area	.161	.354	3.934	.002*	.950
	R = .949, R^2=.900, Adjusted R^2=.877 F=38.972, p=.000, Durbin-Watson =2.014					
More than 20%	Constant	11.396		6.687	.000**	
	Super	.439	.756	9.573	.000**	.746
	Base	.746	.128	1.645	.110	.765
	Area	.185	.319	4.574	.000**	.954
	R = .925, R^2=.856, Adjusted R^2=.842 F=61.364, p=.000, Durbin-Watson =1.716					
More than 10%	Constant	10.460		6.595	.000**	
	Super	.442	.759	11.668	.000**	.822
	Base	1.124	.188	2.919	.006*	.841
	Area	.180	.276	4.569	.000**	.952
	R = .926, R^2=.857, Adjusted R^2=.847 F=82.173, p=.000, Durbin-Watson =1.684					
Less than 10%	Constant	12.470		4.634	.000**	
	Super	.473	.770	7.254	.000**	.784
	Base	1.173	.217	2.076	.054	.808
	Area	.127	.177	1.835	.085	.953
	R = .927, R^2=.859, Adjusted R^2=.832 F=32.382, p=.000, Durbin-Watson =1.305					

* .p < 0.05, **. p < 0.01

Observing the statistical validity of each regression value, all multiple regression models were statistically valid (.000) for super floors. However, when preconstruction ratio was more than 30% base floor was .099; when preconstruction ratio was more than 20% base floor was .110; when preconstruction ratio was less than 10% base floor was .054 and total area was .085 which were all larger than 0.05 making it statistically insignificant. When multiple regression was utilized for projects with preconstruction period was less than 10%, more than 10%, more than 20%, and more than 30%, the slope for the super floor was 0.473, 0.442, 0.439, and 0.422 respectively, which were all statistically significant. Hence, the larger ratio of preconstruction phase resulted in the decrease of the construction period. For example, under the same condition that the number of super floors and total area are equal and for an office building that is 50 floors high, the effect of schedule reduction for more than 30% of preconstruction period and less than 10% of preconstruction period would be the following

Schedule reduction for 50 floor tall office building ① More than 30% of preconstruction period : 0.422 months (12.66 days) increase per 1 super floor ② Less than 30% of preconstruction period : 0.473 months (14.19 days) increase per 1 super floor ③ Difference in construction period per unit floor : 1.53 days (14.19 days – 12.66 days) Schedule reduction effect : about 2.5 months (76.5 days = 1.53 days * 50 floors)

In general, the preconstruction phase is planned long and the construction phase is planned short in western countries, making it capable of completing a project in a short time, creating additional value. Providing sufficient time to perform proper

PCA during preconstruction phase will increase the completeness of the design and minimize design errors and design change during construction phase. Such results will increase the value of the project by successfully performing quality assurance, cost decrease, and securing safety. On the other hand, Korea has a short preconstruction time and long construction time. Also, not only does indirect cost and financial expense increases as construction time increases (Jeong and Lee, 2008), but also the possibility of reducing schedule can decrease. Also, as there was insufficient studying done on the design, there are design errors and design changes during the construction phase. In other words, drawings with less than complete quality will cause various design changes during construction phase, which will directly and indirectly affect the schedule, quality, cost, and safety.

The relationship between PCA and schedule reduction can be summarized as the following. First, the higher a building is and more ratio of preconstruction period is performed, the construction rate per floor decreases. Second, after analyzing the construction rate per floor by categorizing the number of floors, high rise and super tall buildings had the most effect in decreasing the construction rate per floor when PCA is performed. Third, depending on the amount of manpower utilized during preconstruction, it was verified that the more manpower yielded to shorter construction rate per floor for high rise projects. Fourth, this research verified that the more time is invested during the preconstruction phase, total construction period decreased.

5.4 Effects of PCA on Customer Satisfaction and Referral Intention

This section identifies whether the performance of PCA has an effect on customer satisfaction. As such, performance satisfaction of a project, in which the goals of the customer has been achieved, and process satisfaction, the process to achieve the project, is verified. Hence, this research determines whether performance satisfaction and process satisfaction through PCA is capable of achieving customer satisfaction, and ultimately, if customer satisfaction affects NPS.

5.4.1 Effects of PCA on Process Satisfaction

In order to analyze whether there is a difference in process satisfaction depending on how long preconstruction, ratio of preconstruction period was divided into more than 30%, 10-30%, and less than 10%, an ANOVA test was utilized to compare the three averages. The significance probability for process satisfaction was 0.003, which is less than 0.05 proving that there is a difference in process satisfaction depending on the ratio of preconstruction period. Reviewing in details, process satisfaction's preconstruction period of 30% or more, 10~30%, and less than 10% was 8.5123, 8.3535, 6.5458 respectively, shows a distinct difference (Table 5-19). Especially, when the preconstruction period was less than 10%, both performance satisfaction and process satisfaction were evaluated to be in the lower 6. This signifies that performing PCA when construction phase is imminent will not only make it difficult for PCA to perform well but also lead to a low level of satisfaction. After analyzing the relationship between PCA and customer satisfaction, PCA did have a positive impact on customer satisfaction. It appears as if the early involvement of a project manager during the PCA period allowed the owner to trust the provided data as the project manager was actively engaged in the major decision makings from the early stages of the project to project completion.

Table 5-19 Difference between Process Satisfaction during Preconstruction Phase

Independent Variable	Duration of preconstruction	Process Satisfaction Average	Standard deviation	F-value/ Significance
Process satisfaction	More than 30% 10%~30% Less than 10%	8.5123 8.3535 6.5458	.66379 71240 2.83521	6.695/.003*

*P<0.05, **P < 0.01

Note Average: average of the 5 constructs of process satisfaction scored between 1~9

5.4.2 Effects of PCA on Performance Satisfaction

In order to analyze whether there is a difference in process satisfaction depending on how long the preconstruction takes, ratio of preconstruction period was divided into more than 30%, 10-30%, and less than 10%, and ANOVA test was utilized to compare the three averages. The significant probability for performance satisfaction and was 0.013, which is less than 0.05 proving that there is a difference in performance satisfaction depending on the ratio of preconstruction period. For more than 30% during preconstruction phase, performance satisfaction of a project when PCA of 30% or more was 8.3625 points, 10~30% was 7.7009 points and less than 10% was 6.2917 points, which distinctively shows the difference depending on the ratio of preconstruction period (Table 5-20). Hence, not only is performance affected by when PCA is performed during preconstruction phase but also customer satisfaction in terms of performance can differ largely. For projects less than 10% of preconstruction period, after when all major project decisions are done, it is difficult to have a good PCA performance. For example, major decisions are made when the sections and plans, number of super and base floors, groundwork method, heating and cooling system, and exterior material is decided. For instance, if there needs to be a change in earthwork method or the external material, there needs to be changes in the design drawings which require review by the permit government agency. Considering this will have an effect on the construction schedule, it is realistically difficult. It was proven that the longer PCA duration is, construction schedule decreased, and the longer PCA phase was, it led to performance satisfaction. In other words, PCA effected schedule reduction which enhances performance, resulting in performance satisfaction.

Table 5-20 Difference between Performance and Process Satisfaction during Preconstruction Phase

Independent Variable	Duration of preconstruction	Performance Satisfaction Average	Standard deviation	F-value/ Significance
Performance satisfaction	More than 30% 10%~30% Less than 10%	8.3652 7.7009 6.2917	.72894 1.26705 3.21563	4.826/.013*

*P<0.05, **P < 0.01

Note Average: average of the 2 constructs of performance satisfaction scored between 1~9

5.4.3 Effects of Customer Satisfaction on Referral Intention

1) Data for Performance satisfaction, Process satisfaction and Referral Intention

KS-SQI model uses a 9 point Likert scale for each question, and calculates the overall score based on the individual weights. 9 point scale is much more diversified than 5 point or 7 point scale which makes it possible to evaluate customer satisfaction with more precision. KS-SQI is evaluated twice a year and is scored on a 100 point scale, each point would be 12.5 points apart. The KS-SQI score is multiplied with the weight for each construct and reflects the sum of the 7 constructs (primary needs fulfillment, unexpected benefits, reliability, individual empathy, positive assistance, accessibility, and physical environment). Performance satisfaction is the average score of the 2 constructs (primary needs fulfillment, and unexpected benefits), and process satisfaction is the average score of the 5 constructs (reliability, individual empathy, positive assistance, accessibility, and physical environment). There are no additional weights for process or performance satisfaction. Since this research extracted only the office building and mixed-use buildings among the projects surveyed by KS-SQI, it was not possible to calculate the weights for each construct that was utilized for every half year. Hence, 9 point scale raw survey data for process satisfaction and performance satisfaction was utilized. Referral intention is score used to evaluate NPS and is scored from 0~10. Since it was not possible to utilize the NPS value by subtracting the detractors from promoters to determine the correlation and regression analysis between process satisfaction, performance satisfaction, and referral intention, raw NPS survey data that was responded by customers on an 11 point scale (0-10 points) was applied.

2) Correlation between Performance satisfaction, Process satisfaction and Referral Intention

Based on the KS-SQI data ranging from 2012 to 2015, correlation between referral intention and performance satisfaction, and process satisfaction was analyzed. The results showed that both performance satisfaction and process satisfaction have high correlation with referral intention (Table 5-21). As seen in

Table 5-21, although the correlation value between referral intention and process satisfaction is 0.756, correlation value between referral intention and performance satisfaction is 0.810, which means referral intention had higher correlation with performance satisfaction rather than process satisfaction.

Table 5-21 Correlation between Performance, Process and Referral Intention

	Average	**Standard Deviation**	**Inter-Construct Correlations**		
			1	**2**	**3**
1. Performance satisfaction	7.9105	1.39587	1		
2. Process Satisfaction	8.2757	1.11869	.878**	1	
3. Referral Intention	9.07	1.497	.810**	.756**	1

** Correlation is significant on both sides with value less than on 0.01

3) Effects of Performance satisfaction and Process satisfaction on Referral Intention

Regression analysis was utilized to identify the relationship between referral intention and performance satisfaction, and process satisfaction. Both performance and process satisfaction had a positive effect on referral intention. Based on the regression model for performance satisfaction and referral intention was when $\rho = 0.000$ F-value was 83.944 and a t-value of 2.884 (P=0.000), which is statistically significant. The R^2 of 0.656, or explanation power of 65.6%, was also high. Hence, the independent variable, performance satisfaction, is capable of explaining the dependent variable, referral intention. When interpreting the regression equation, if 1 point increases for performance satisfaction, referral intention increases by 0.869. The regression model for process satisfaction and referral intention was when $\rho = 0.000$ F-value was 58.748 and a t-value of 7.665 (P=0.000), which is statistically significant. The R^2 of 0.572, or explanation power of 57.2%, was also reasonable. When 1 point increases for process satisfaction, referral intention increases by 1.012 points (Table 5-22). Hence, process satisfaction had a more significant role in increasing referral intention.

Table 5-22 Comparison of Regression Model on Performance Satisfaction, Process Satisfaction, and Referral Intention

Independent Variable	**SE**	***b***	**t-value**	**Significance**	**Statistics**
Performance satisfaction	.095	**.869**	2.884	.000**	R = .810, R^2=.656 Adjusted R^2=.648 F=83.944, p=.000
Process satisfaction	.132	**1.012**	7.665	.000**	R = .756, R^2=.572 Adjusted R^2=.562 F=58.748, p=.000

** Significant at p-value < 0.01, Dependent variable: referral intention
b value: the change in independent value, referral intention, when dependent value increases by 1point

4) Correlation Analysis between Referral Intention and 5 Constructs of Process Satisfaction

In order to determine the relationship between process satisfaction and NPS, correlation analysis was performed for the 5 constructs of process satisfaction and NPS. The correlation between NPS and reliability, individual empathy, positive assistance, accessibility, and physical environment was 0.792, 0.700, 0.686, 0.665, and 0.612 respectively (Table 5-23). Hence, among the constructs in process satisfaction, reliability had the highest impact in enhancing NPS. CM manages a project in lieu of the owner who lacks the specialized skills. Also, when design change occurs due to the owner or constructor, CM reviews the appropriateness of the schedule, quality, and cost. Therefore, the trust relationship between the owner and CM is a prerequisite in project management. Therefore, it is possible to assume reliability has the highest relationship in increasing NPS.

Table 5-23 Correlation between Process Satisfaction and Referral Intention

	Average	Standard deviation	Inter-Construct Correlations					
			1	2	3	4	5	6
1. Referral Intention	9.07	1.497	1					
2. Reliability	8.2826	1.19664	.792**	1				
3. Individual empathy	8.2536	1.24560	.686**	.897**	1			
4. Positive assistance	8.0489	1.49222	.700**	.840**	.951**	1		
5. Accessibility	8.4022	1.13343	.665**	.720**	.810**	.806**	1	
6.Physical environment	8.3913	1.02693	.612**	.652**	.711**	.669**	.898**	1

** Correlation is significant on both sides with value less than on 0.01

5) Conception of 5 constructs of Process Satisfaction based on Referral Intention

ANOVA analysis was utilized to identify the difference between the 5 constructs of process satisfaction (reliability, individual empathy, positive assistance, accessibility, and physical environment) with promoters, passively satisfied, and detractors. The results showed that there was a significant difference between the promoters, passively satisfied, and detractors with the 5 constructs of performance satisfaction. Both promoters and passively satisfied customers scored 8 points. On the other hand, detractors were a low score between 4-6. Especially, to identify if there is a significant difference between promoters, passively satisfied, and detractors with the 5 constructs of process satisfaction, Dunnett T3, ad-hoc validation, was utilized. The results showed that promoters and detractors, passively satisfied and detractors have a significant difference between the groups in reliability. However, individual empathy, positive assistance, accessibility, and physical environment did not show any significance for promoters, passively satisfied, or detractors (Table 5-24). This may be due to the fact CM is taking the role as the owner, who has no expertise in construction, to determine issues and make major decisions. The transparency of information during this process might have been the most important factor.

Table 5-24 ANOVA Analysis of Referral intention and 5 Constructs of Process Satisfaction

Dependent variable	Type	Average	Standard deviation	F-value /significance	Post-hoc multiple
Reliability	Promoter (a)	8.6574	.64972	33.629/.000**	a,b>c Dunnett T3 verification
	Passively satisfied (b)	8.2000	.44721		
	Detractors (c)	5.6667	1.54560		
Individual Empathy	Promoter (a)	8.5833	.63434	25.094/.000**	-
	Passively satisfied (b)	8.4667	.50553		
	Detractors (c)	5.6667	2.06828		
Positive Assistance	Promoter (a)	8.4722	.84468	25.618/.000**	-
	Passively satisfied (b)	8.1000	.67546		
	Detractors (c)	4.9500	2.17514		
Accessibility	Promoter (a)	8.6806	.63418	19.149/.000**	-
	Passively satisfied (b)	8.6000	.54772		
	Detractors (c)	6.2000	1.95576		
Physical environment	Promoter (a)	8.6250	.56537	13.219/.000**	-
	Passively satisfied (b)	8.5000	.50000		
	Detractors (c)	6.6000	2.07364		

** The mean difference is significant at the .001 level

The relationship between PCA and customer satisfaction, and referral intention can be summarized as the following. First, when PCA is performed early in the project where the project directivity can be adjusted, customer satisfaction (performance satisfaction, process satisfaction) was high. On the other hand, when CM manpower is implemented to perform PCA after all major decisions are made during preconstruction phase, customer satisfaction (performance satisfaction, process satisfaction) was low. Second, there is a high correlation between referral intention and performance satisfaction, and process satisfaction. Process satisfaction also has a significant role in enhancing referral intention. Especially, reliability, a factor of customer satisfaction, is not only a critical factor in enhancing referral intention but also a factor that determines promoters, passively satisfied, and detractors. In other words, it is possible to acquire promoters by managing the project success factors (schedule, quality, cost, safety) at the early stages of a project and achieve the customer's goal, which will turn out to be customer satisfaction.

5.4.4 Trend Analysis for PCA Duration, Customer Satisfaction, and Referral Intention

Customer satisfaction and referral intention trend was analyzed based on PCA duration. Data used for the trend analysis is data gathered by H-company between 2007 and 2015 every half year. Since referral intention is an evaluation criteria of NPS which measures the customer's intention to refer, it is evaluated between 0 to 10. The survey data for referral intention also ranges from 2007 to 2015. To determine the trend for referral intention, projects that have performed NPS at least 2 times were utilized. For projects that did perform PCA, projects that performed NPS during preconstruction phase at least once were selected. Since customer satisfaction (KS-SQI) survey began in 2012, data ranging from 2012 to 2015 were used. As a result, a total of 33 projects and 50 customers were subject for this analysis (Table 5-25).

Table 5-25 Trend Analysis Subject for PCA Duration, Customer Satisfaction, and Referral Intention

Ratio of Preconstruction Phase	Number of Projects	Number of Customers
More than 30%	11	16
10~30%	9	13
Less than 10%	13	21
Sum	33	50

Correlation between customer satisfaction and referral intention data were analyzed which was derived from the customer satisfaction and referral intention trend analysis data (Appendix 5). The results showed that there is a very high correlation (.878**) between customer satisfaction and referral intention. Correlation between customer satisfaction and referral intention during preconstruction phase, and construction phase was .977** and .876** respectively (Table 5-26). Therefore, satisfaction during preconstruction phase has a larger role in increasing the referral intention than that of the construction phase.

Table 5-26 Correlation between Customer Satisfaction and Referral Intention through Trend Analysis

	Preconstruction Phase	**Construction Phase**	**Total**
Correlation between customer satisfaction and referral intention	.977**	.876**	.878**

** Correlation is significant on both sides with value less than on 0.01

The results were divided into 3 types of pattern (A, B, C) depending on the trend of the referral intention. Pattern A is when the referral intention is the same at the end of project and early project. For example, when a customer is a promoter at the beginning of the project and is still a promoter at the end of a project. Pattern B refers to when referral intention improved at the end of project from early project. For example, when a passively satisfied customer at the beginning of a project becomes a promoter by the time the project completes. Patter C refers to when a customer's referral intention decreases by the end of project completion

Table 5-27 Pattern Categorization based on Referral Intention Trends

Pattern	**Referral Intention Trend**
A	Referral intention is the same at the end of project and early project
B	Referral intention improved at the end of project from early project
C	Referral intention decreased at the end of project from early project

The result of analyzing the trend pattern based on PCA ratio is shown in Table 5-28.

Table 5-28 Trend Analysis of Referral Intention based on PCA Period

Pattern	More than 30% PCA period (n 16)	10~30% PCA period (n 13)	Less than 10% PCA period (n 21)
A	56 %	62 %	57 %
B	38 %	15 %	14 %
C	6 %	23 %	29 %
Sum	100 %	100 %	100 %

Figure 5-9 is a graph based on Table 5-28, and it can be summarized as the following:

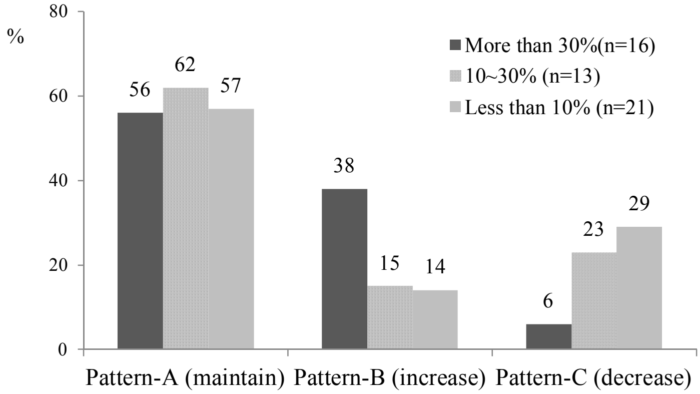


Figure 5-9 Comparing Patterns on Preconstruction Period and Referral Intention

(1) When PCA Period is more than 30%

Pattern A (maintain) was between 56~62%. Especially for when PCA duration was more than 30%, promoters were 100% maintained by the end of the project. Meanwhile, when PCA duration was 10~30%, and less than 10%, detractors or passively satisfied customers at the beginning of a project were still detractors or passively satisfied at the end of the project. Pattern B (increase) was 38% which shows that the longer PCA duration, the more positive effect it will have on referral intention by the end of the project. Pattern C (decrease) was 6% which represents that there are very few projects where the referral intention decreases during project completion.

(2) When PCA Period is between 10~30%

Pattern A (maintain) showed a high value of 62%. However, when PCA duration was between 10~30%, high referral intention was not maintained by the end of the project. For example, a detractor at the beginning of a project was still a detractor at the end of the project (Case 29 in Appendix 5). Pattern B (increase) , which has a positive impact on referral intention at the end of a project, was 15% which was relatively much lower than Pattern A (maintain). Pattern C (decrease), where the referral intention decreases, was 23% which is a drastic increase from when PCA duration was more than 30%.

(3) When PCA Period is less than 10%

Pattern A (maintain) was 57% and there were cases where a passively satisfied customer was still a passively satisfied customer by project completion (Case 35, Case 48, Appendix 5). Pattern B (increase) was 14% which is similar to when PCA duration was 10~30%. Pattern C (decrease) was 29% which was significantly higher than the 6% when PCA duration was more than 30%.

In conclusion, when PCA is performed at the early stages of a project, it is possible to achieve a high referral intention by the customers, and it can have a positive influence in maintaining the high referral intention by the end of a project. This is possibly due to the fact that the longer PCA allows the owner's requirements to be applied into the design drawings, and the product satisfies the customer.

However, if PCA duration is lacking, the owner's need will not be sufficiently applied to the design and not enough time is allocated for design review leading to lower productivity during construction phase. Also, a profound relationship was found between referral intention and customer satisfaction. When referral intention is high during construction phase as well as preconstruction phase, customer satisfaction will be high. Meanwhile, if referral intention is low, customer satisfaction will also be low, showing a close relationship between the two elements.

5.5 Effects of PCA on NPS

This section attempts to prove that PCA performance, which leads to satisfied customer, can bring promoters by utilizing NPS. This is an attempt to show that not only is PCA capable of enhancing performance through quantitative input of resources but also lead to customer satisfaction and eventually customer recommendation.

5.5.1 Effects of PCA Duration and Manpower Investment on NPS

Difference of NPS was analyzed depending whether a project performed PCA. According to the analysis, for projects that performed PCA, 76.5% of 68 customers were promoters, 16.2% were passively satisfied, and 7.3% were detractors. According to the NPS equation, promoters subtracted by detractors is 69.2. On the other hand, for projects that did not perform PCA, of the 25 customers, 60.0% were promoters, 24.0% were passively satisfied, and 16.0% were detractors. According to the NPS equation, promoters subtracted by detractors is 44.0 (Table 5-29). As a result, the difference of NPS between a project with PCA and without PCA was

25.2. This conclusion represents that there is a significant difference in the number of promoters after project completion between a project when a construction manager is implemented during construction phase to manage the project according to the drawings, and a project where PCA is utilized to managing the project during preconstruction phase. In other words, it is a product of much effort and thought to achieve the project performance through PCA.

Table 5-29 NPS on With PCA vs Without PCA

	n	Promoters A	Passively satisfied B	Detractors C	NPS A-C
With PCA	68	76.5%	16.2%	7.3%	69.2
Without PCA	25	60.0%	24.0%	16.0%	44.0

n : Number of respondents

NPS for projects that performed PCA and projects that had not performed PCA was graphed as shown in Figure 5-10, which shows a difference of 16.5% in the promoter ratio. Also, there was a significant difference of 25.2% in NPS between projects that had performed PCA and projects that did not perform any PCA. A promoter will not only repurchase service from the company but will also recommend others about the service, which is extremely useful and an important index in the construction industry.

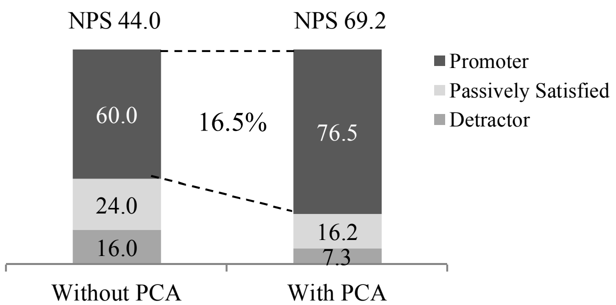


Figure 5-10 PCA and NPS

5.5.2 Effects of PCA Period on NPS

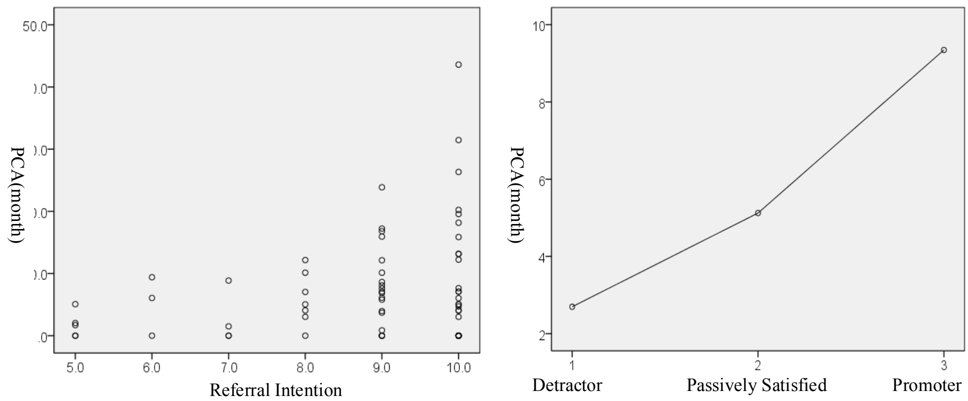
After analyzing the preconstruction phase period with amount of manpower utilized based on promoters, passively satisfied, and detractors, there was a distinct difference based on the referral intention (Table 5-30). Comparing the preconstruction phase average period, promoters was 9.3 months, passively satisfied was 5.1 months and detractors were 2.6 months. As shown in the analysis, there was a large difference between promoters and detractors based on the preconstruction period. For example, when insufficient PCA period is secured and PCA is performed, it would be difficult in acquiring promoters. It can be said that utilizing competent manpower at the beginning stage of a project for PCA is most ideal in acquiring promoters. It is up to the owner when and how many people will be implemented for PCA. Therefore it is very important for the owner to understand the importance of PCA and performing PCA appropriate to the project characteristic.

Table 5-30 Time Invested during Preconstruction Phase based on Referral Type

	n	Time Invested during Preconstruction Phase	
		Average (month)	**Standard deviation**
Promoters	67	9.346	8.9801
Passively satisfied	17	5.124	5.5458
Detractors	9	2.696	3.3991
Sum	93	7.930	8.3547

n : number of respondents

The relationship between preconstruction period and referral intention was plotted which shows that longer preconstruction phase led to higher referral intention (Figure 5-11a). Also, the graph is distinctively separated based on the referral intention (promoters, passively satisfied, and detractors) (Figure 5-11b).



(a) Scatter Plot of PCA Period and NPS (b) Graph of PCA Period and NPS

Figure 5-11 Time Invested on Preconstruction Phase and NPS

Figure 5-12 shows that when the ratio for preconstruction phase is more than 30%, ratio of promoters were 92.8% which is 26.1% higher than 10~30% of preconstruction, and 34.2% higher than less than 10% of preconstruction. Hence, the more preconstruction phase is implemented, the ratio of promoters increase drastically. Such conclusion can be drawn because the performance of the project reflects the preparation during the early stages of preconstruction phase which is then applied during construction. Also, it is also a result of establishing an organization based on project stakeholders in order to adjust the overall schedule in accordance with the project directivity. On the contrary, for projects with less than 10% of preconstruction phase, PCA is performed at the late stages of the preconstruction phase. In other words, it is difficult for PCA to perform as desired when major decisions are made on the design drawings and the project, which is why NPS is rather low.

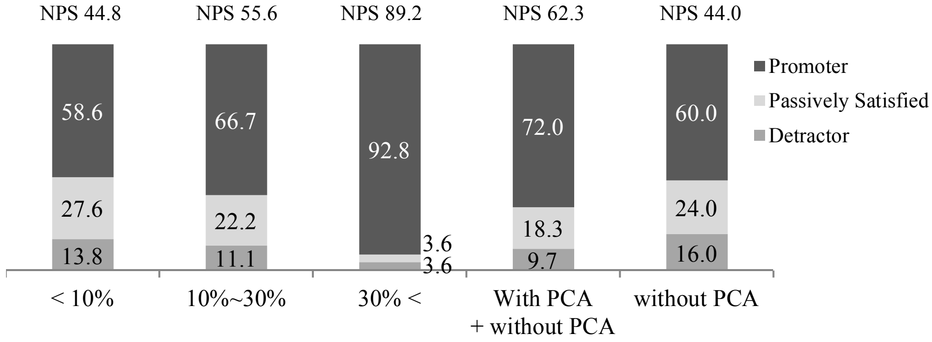


Figure 5-12 Time Invested during Preconstruction Phase and NPS

5.5.3 Effects of PCA Manpower on NPS

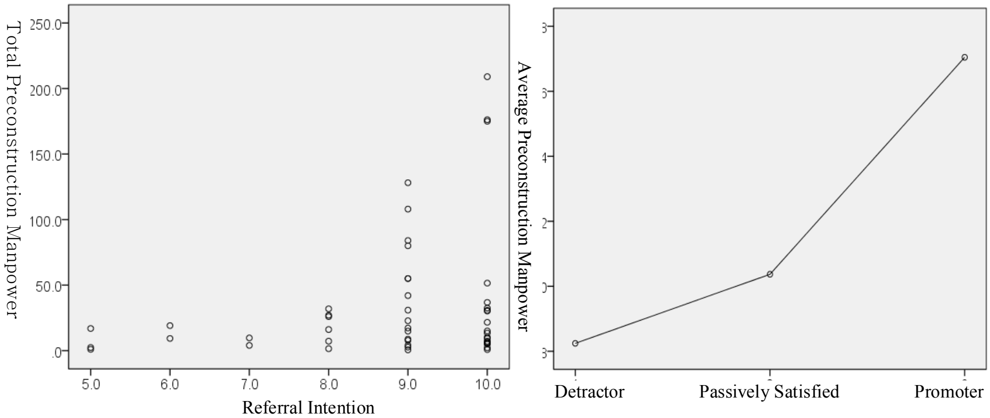
Ratio of manpower utilized during preconstruction phase was divided promoters, passively satisfied, and detractors as shown in Table 5-31. Average manpower invested during preconstruction phase for promoters, passively satisfied, and detractors was 17.0%, 13.3%, and 8.2% respectively. Ratio of manpower invested for promoters were two times higher than that of the detractors, which shows that more manpower were used to prepare in advance for project success.

Table 5-31 Manpower Invested during Preconstruction Phase based on Referral Type

	n	**Manpower Invested during Preconstruction Phase**	
		Average (%)	**Standard deviation**
Promoters	67	17.046	11.5514
Passively satisfied	17	10.369	8.9605
Detractors	9	8.244	15.6285
Sum	93	14.974	16.8045

n : number of respondents

The dispersion graph between manpower utilized during preconstruction phase and referral intention describes that the more manpower utilized yields to higher referral intention (Figure 5-13(a)). Also, Figure 5-13(b) represents a dispersion graph when promoters, passively satisfied customer, and detractors are groped based on the amount of manpower utilized during preconstruction as shown in Table 5-31.



(a) Scatter Plot of PCA Manpower and NPS (b) Graph of PCA Manpower and Referral Intention

Figure 5-13 Scatter Graph for Manpower Invested on Preconstruction Phase and NPS

Ratio of manpower utilized during preconstruction phase was divided to more than 30%, 10~30%, and less than 10%, and its relation with NPS is shown in Figure 5-14. Based on the results, for projects with more than 30% of manpower, 10~30% of manpower, and less than 10% of manpower during preconstruction phase yielded to an NPS of 92.3, 59.5, and 55.3 respectively. Also, projects with zero manpower during preconstruction phase yielded to an NPS of 44.0. Hence, the more manpower is utilized during preconstruction phase leads to higher NPS. This conclusion defines that PCA had been actively pursued all throughout the construction sectors. Especially, as the promoter's ratio for projects with more than 30% of manpower utilized during preconstruction phase was 93.2%, it has a very high potential in acquiring promoters. Furthermore, there was a large difference of 48.3 points in NPS between projects with more than 30% of manpower utilized during PCA and projects without PCA

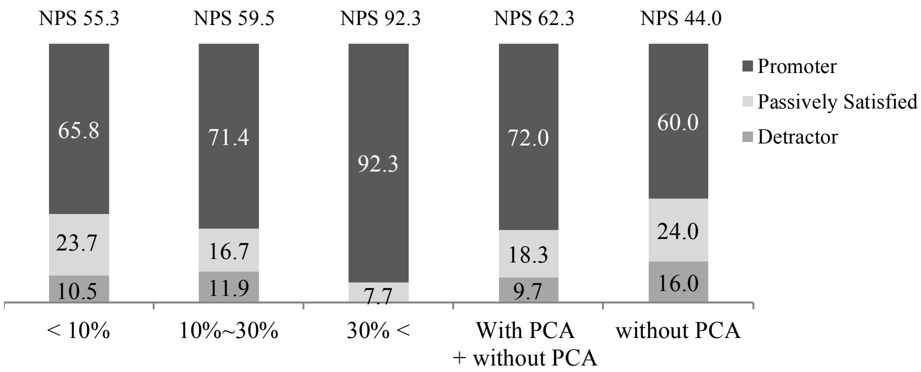


Figure 5-14 Manpower Invested in Preconstruction Phase and NPS

5.6 Summary

This chapter verified that it is possible to acquire customer loyalty by achieving customer satisfaction, which is realized by performing PCA to reduce schedule and contribute to the project success. Although this research analysis focused on schedule for PCA performance, performance of PCA affects not only schedule but also quality, cost, safety, and other success factors for a project, which is interpreted to a satisfied customer. The research findings can be summarized as the following:

(1) To verify the application of PCA evaluation form, it was applied to real cases. Based on the results, the higher PCA evaluation score yielded to a the higher NPS and longer PCA duration. As a result, PCA duration, PCA evaluation score, and NPS have a profound correlation, and the PCA evaluation form developed in this research was proven to be a useful tool.

(2) The relationship between PCA and schedule reduction was analyzed. Based on the results, the longer PCA duration and higher ratio of PCA manpower yielded to the reduction of construction rate per floor. Especially, schedule reduction effect was maximized when PCA period was more than 30% and PCA manpower was 15%. After analyzing PCA and construction rate per floor, PCA had a better schedule reduction effect on tall to super tall projects. Analysis results between PCA duration and total construction period showed that total construction period decreased as PCA duration increased. Such results where construction schedule is decreased were derived when PCA is performed early during preconstruction phase. Also, it was proven that PCA for tall projects was much more effective in reducing schedule.

(3) The relationship between PCA and customer satisfaction showed that PCA duration and performance satisfaction, and process satisfaction had a positive relationship. In other words, both performance and process satisfaction scores increased as PCA duration increased.

(4) Based on the correlation between customer satisfaction and referral intention analysis, process satisfaction was capable of enhancing the referral intention. Reliability, a construct of process satisfaction, had a high correlation with referral intention. Also, reliability was also an important factor that determined a promoter, passively satisfied, and detractors.

(5) There was a profound relationship between customer satisfaction and referral intention based on the trend analysis of referral intention within the project lifecycle. It was possible to maintain a high referral intention at the end of the

project when PCA was performed longer. Also, there was a large difference when comparing the increase of referral intention ratio during beginning of the project and end of the project. Projects with more than 30% of PCA was 24% higher than projects with 10~30% of PCA.

(6) Analyzing the relationship between PCA and NPS, projects that performed PCA scored 25.2 points higher in NPS than projects that did not perform PCA. Especially, there was 16.5% difference in the ratio of promoters. The longer PCA duration was and more PCA manpower was utilized, a high NPS was seen. Projects with a ratio of preconstruction manpower of 30% or more had 92.3% promoters, which was an excellent performance in acquiring promoters.

The success of a project depends on how the competent project management organization is involved early in a project, and how well PCA is performed. This research verified that it is possible to decrease schedule when a competent project management organization plans for construction during project initiation phase through real case studies. In other words, this research verified the virtuous cycle of competitive design → high quality and competitive construction → project success → customer satisfaction → referral intention (NPS) is valid. Due to the characteristic of a construction project, PCA depends on the contract conditions. Also, as the owner decides on how much time and manpower will be invested during preconstruction phase, it is very important to develop awareness on PCA in order to plan in advance on how PCA will be performed by the skilled manpower as well as to acquire enough time to perform PCA for the success of the project.

Chapter 6. Conclusion

Recently, many construction projects have increased in scale as well as its complexity, increasing the risks associated in carrying out the construction project. In order to reduce the risks, it is very important to implement a systematic project management at the early stages of a project. However, Korean companies, in practice, tend to omit or be indifferent about the early stages of the project. Instead, they have a habit of tending the issues in the future. As such, repetitive trial and errors have occurred and have caused a number of poor performance.

The goal of this research is to highlight the importance of PreConstruction Activities (PCA) when executing a construction project. Also, this research attempts to prove that PCA has a significant correlation with schedule reduction. Furthermore, when PCA leads to performances such as schedule reduction, it is possible to provide customer satisfaction. The research continues to prove that it is possible to achieve customer satisfaction which can lead the satisfied customer to recommend and enhance the customer loyalty index called the net promoter score (NPS). Then, a PCA evaluation form is developed to determine whether PCA is performed adequately. This can be summarized as the flowsheet shown below.

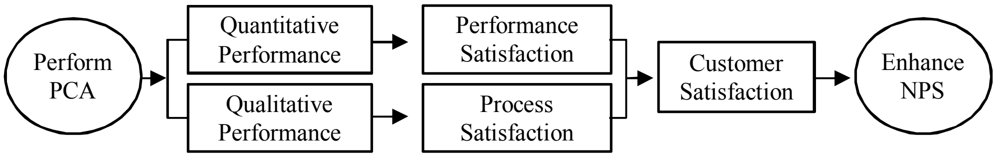


Figure 6-1 Research Process

The results and summary of this research, the research contribution, and future studies are summarized in following sections.

6.1 Research Results and Summary

3 main problems were suggested by this research

- Lack of knowledge on the importance of preconstruction phase and the negligence of PCA.
- As such, level of customer satisfaction has decreased due to lack of performance after the project has been completed.
- There is a lack of verification system or evaluation method to check how well PCA is performed.

The research was carried out based on these problems and the following results were found.

(1) PCA is to develop professional service to execute the construction project and a method to achieve the project goals, such as cost, schedule, and quality, by simulating prior to construction initiation. These goals are eventually achieved through the drawings and PCA is concluded by developing a competitive design as well as selecting a capable construction team.

As a result, aside from the good project performance, as long as competitive and complete design and an outstanding project team are acquired, it will help successfully achieve the owner's quantitative goals. In addition, it is possible to perform even better by having early involvement of the general contractors, CM-at-risk companies, and other specialized contractors through partnering or integrated project delivery (IPD).

This research has pointed out the importance of PCA in terms of the success or failure of a project. Also this research has proved that schedule reduction is possible through PCA based on the data derived from customers.

(2) Customer satisfaction is a necessity in order to survive in every industry. Considering word of mouth or reputation is more important in the construction industry than any other industry, customer satisfaction is essential in order to win future contracts. In the construction industry, the issue of customers requesting repeat orders from a single company and how much it contributes to the company's profit creation had been discussed as well.

This research proves that it is possible of achieving customer satisfaction through PCA based on qualitative performance, such as reliability, individual empathy, positive assistance, etc., as well as quantitative performance, such as cost reduction, schedule reduction, etc.

(3) For a company to grow, repurchase rate by core customers with high loyalty has to increase. Pareto's 80:20 Law can be applied in a similar concept for key customers: the core 20% of customers can yield 80% of the entire profit for a company, and therefore maintaining the key customer would largely contribute to the profit of a company.

Net Promoter Score (NPS) is a very powerful tool that is utilized by global companies in order to determine the client loyalty by asking a very simple question.

When the referral intention is high for a client, the client is a “Promoter” with high satisfaction on the service. This research proves that PCA can lead to customer satisfaction and eventually to become a loyal customer.

When PCA accounted for more than 30% of the entire duration, there was a 45.3 point difference in NPS when comparing it to a project without PCA. There was an NPS difference of 48.3 points comparing more than 30% of PCA manpower to without PCA. Simply comparing whether a project performed PCA or not, there was a 25.2 point difference. Hence, this research proved PCA can improve NPS and acquire loyal customers which depend on the duration of PCA and amount of manpower involved.

(4) Although it is also important whether PCA is performed or not, which has a significant impact on project success, a verified and competent team that can perform PCA well is also very important. In order to do so, a verification system to assess PCA is needed. In order to develop the verification system, PCA evaluation form based on critical success factors (CSFs) were extracted. Then, a pilot test on projects that performed PCA was initiated to verify the effectiveness of the PCA evaluation form. The results proved that a correlation existed between the duration of PCA and amount of manpower involved with the evaluation score. As such, this also proved that the PCA evaluation form can be utilized as a tool in order to determine how well PCA is performed in a project.

6.2 Research Contributions

The academic contribution of this research is that the importance of preconstruction phase in a construction project has been highlighted with many examples. Also the importance of PCA performed during this phase was also thoroughly studied, and through various examples of schedule reduction, this research proved the correlation between PCA and schedule reduction. Then, the concept and idea of customer satisfaction that has been neglected in the construction industry was discussed. Furthermore, the concept of NPS that is rarely implemented in construction industry was also introduced. Then, the cycle between PCA and NPS was analyzed and the correlation between the two was revealed. The findings can be summarized as the following.

(1) The categorization of PCA, schedule, customer satisfaction, NPS, design management, and best practice methods were all connected and the importance of PCA in terms of project success was discussed. As a result, it was possible to establish the concept and importance of PCA. Especially, the capability of reducing schedule through PCA was proved by analyzing the Empire State Building (ESB) construction project, and based on the results, methods to reduce schedule was suggested. Should the suggested methods be utilized, it would be possible to achieve great performance for cost, quality, safety and other areas.

(2) This research proved that it is possible to achieve schedule reduction, including customer satisfaction through quantitative and qualitative

performance, with PCA. Then, the virtuous cycle of how the satisfied customer can become a loyal customer which will increase the NPS was also proved. As a result, it is possible to increase the customer loyalty index, NPS, through PCA.

(3) PCA evaluation form was developed as a tool to verify how well PCA is performed. If the evaluation form is slightly modified, the PCA evaluation tool can be become tool that can be applied to other fields including civil, plant projects. As such, checking if PCA is performed properly in advance can help contribute to the project success.

(4) Customer satisfaction and NPS-related research from this research can be utilized by other construction firms. Especially, that there was a lack in customer satisfaction activities in Korea and only a few companies managed their NPS. Therefore this research contributed to the industry by underlining the need for management of customer satisfaction in the construction industry.

(5) Repetitive repeat orders by loyal customers who are satisfied with the service by construction companies can result to profit. Through word of mouth and recommendation, it is possible to bring in new potential customers. This research proved that the virtuous cycle is possible and suggested a new paradigm for the management.

6.3 Further Study

This research concerns PCA and schedule reduction. It is also a research on customer satisfaction and customer loyalty index, NPS. However, there is a limitation in the amount of research performed in Korea concerning the keywords. Furthermore, there was very little research available on NPS in the construction industry. As a result, the author's opinion and experience in the field was incorporated in the research paper.

Based on this research, the further study required would be the following.

(1) There needs to be an in-depth research on the effectiveness of PCA. PCA can contribute to cost and quality management, as well and the project success. A long-term research study is needed on a real construction project which tracks the project from the beginning to the end. In addition, in-depth research on the correlation between customer satisfaction and PCA is also necessary.

(2) Research to develop a Body of Knowledge on PCA is needed. The categorization and contents by both PMI and CMAA are very different, and the concept and approach of PCA is different from the US and the UK. Therefore, PCA Body of Knowledge should be developed, in consideration of the policies and contract methods in Korea.

(3) More research on the PCA methodology is required. Both PMI and CMAA provide a guideline and activities for each phase but that is the limit. The industry requires research that will provide more detailed activities and a tool kit or a manual that can be applied. Through this would it be possible for PCA as a tool to further achieve project success.

(4) Research on customer satisfaction in construction is necessary. For a sustainable company, the company must be welcomed by the customer. In Korea, construction dispute cases compose the largest ratio for specialized

sectors[9] in the Seoul Civil Court. This reflects the large amount of disputes with clients and customer satisfaction is not being achieved. Since repurchase by core customers is extremely important in the construction industry, there needs to be a research to verify customer satisfaction in construction. Research is needed on how the management of customer satisfaction effects the management and the sustainable management of a company, and how it affects the company revenue.

Furthermore, study on core customers and loyal customers in construction are needed. More examples and research on NPS is needed for the construction industry.

(5) The PCA evaluation form tool that was developed in this research needs to be further verified in other projects types through research. Also, other than the duration of PCA and the amount of manpower utilized, and the evaluation scores, an evaluation form that has a correlation with customer satisfaction and NPS has to be verified. This research performed a pilot test with the developed PCA evaluation form on a real project, but there needs to be more various types of projects for verification. Also, after verifying the evaluation form with the projects, a standard to evaluate the state of the project is needed. However, this research did not address the needed standards, and as such, a standard to determine the suitability of PCA derived from the evaluation form is necessary.

[9] Currently there are a total of 41 civil agreement courts within the Seoul Central District Court. Among the civil agreement courts, six concerns specialized construction courts (eight courts if including real estate (redevelopment) in the construction sector) which is significantly higher than other specialized courts where only one or two courts are assigned. Since each specialized court handles about 100 construction cases, the amount of civil cases would exceed any other industries (Yun, 2005).

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Appendix

Appendix 1: Evaluation form Manual for Successful PCA

SECTION Ⅰ – STRATEGY

<u>CSF 1. Setting Goals: Establish goals based on project objectives and directivity</u>

'Goal setting' is defining an goal where the success of a project can be measured. In order to achieve such goals, the specific intention and directivity of the project is set. 'Goal' can be divided into business objectives and project objectives. Business objectives represent the strategic/organizational goal of the owner that needs to be achieved through the project. This may change depending on the project type, characteristic, and owner's will. Meanwhile, project goal represents the common performance index, such as schedule, cost, quality and so forth, which does not depend on the project type.

1-1. Owner's definite vision and goals (Business Objectives)

Since the project success is evaluated based on the goals set by the owner's chief executives, the owner's chief executives need to clearly establish the project vision and philosophy, which has to be shared with all project participants. By establishing the project vision and philosophy when project initiates, it is possible to establish priorities of the project and decide what to request from the project participants.

1-2. Establish feasible project objectives

Although project goal is composed of common performance index, such as cost, schedule, and quality, unrelated to type of projects, the objectives may change depending on the support by the owner's chief executives.

CSF 2 Establish Execution Plan: Establish a realistic and achievable execution plan

A realistic and achievable execution plan must be established beforehand for project success.in order to achieve both project goals and objectives of the owner. Establishing execution plan is to maximize the possibility of project success. Therefore it is an essential process in extracting necessary strategic information to evaluate risk or distribute resource effectively. It can be divided into plans in terms of business and project execution plan.

2-1. Owner's systematic project strategy and plans

Owner's chief executive must establish a strategic project goal based on clear project vision and commitment, and a project execution plan needs to be established in order to achieve it. In order to do so, owner's requirement and design requirement must be clearly precisely drafted. Laws, policies, and other risks including external environment factors must be analyzed in depth and applied to the execution plan.

2-2. Establish project execution plan

A systematic project execution strategy must be established before initiating the project. Also, in order to complete the project under the provided time, a masterplan that provides a general guideline on what tasks must be done by the owner from the design stage to construction, and operation and maintenance phase should be developed. The execution plan is composed of project organization plan, design and engineering plan, procurement plan, construction plan, and facility operation plan.

CSF 3. External environment analysis: Active measures on external factors that affect the project

For project success, it is important to predict the economic, social, and political environment factors that may affect the project must and take proper measures. These environmental factors are generally used in evaluating the feasibility of a project. Since such factors can delay or even stop the project, constant monitoring of the factors and appropriate measures when a problem arises is necessary.

3-1. Analyze internal & external economic/social/political environment

Internal and external economic, social, and political environment affects whether the project will initiate and when the project will initiate, and ultimately can have an impact on the project success. As such, it is important to constantly predict the environment that surrounds the project throughout the project, and take measures when there are changes. Various risks, such as internal and external economic, social and political environment analysis, including permits (local government), must be analyzed.

3-2. Review applicability of related policies or laws

A construction project is affected by a number of laws and policies from the project initiation to project completion. Such factors are fundamental factors in setting the direction of a project. To determine whether the project is in accordance with the related laws or policies, a thorough understanding of the laws and policies is needed as well as its effect on the project.

SECTION Ⅱ – ORGANIZATION

CSF 4. Organizational Structure: Establish a systematic and efficient organizational structure

Decision making committee organization composed of owner, designer, constructor, and construction manager exists for all construction projects. Through the organizational structure, formal authority and communication system is established. Therefore, before defining the necessary roles and responsibility, reporting system and so forth, what type of organizational structure and how the owner's organization, including external organization will be selected must be considered first. Based on the organization, the process of appropriate task distribution will be followed.

4-1. Create an organization (team) based on expertise and efficiency

In order to achieve the project vision and goals, it is necessary for the owner to create a competent team. The scale of the team may differ depending on the project size and complexity, but it must be composed of members who have various types of expertise. Sometimes it will be necessary for an external expert to participate who has specialized experience for a specific project.

4-2. Select competent project stakeholders and utilize experts

It is essential for PM/CM to participate in order to select competent project participants and bring in the best experts in the field. Selecting and utilizing the organization at the right time is very important for a flawless process. For example, for a super tall building project, earth, structure, vibration, curtain wall, elevator, MEP, window washing, wind test and other experts will participate from the design stage and continue to provide consultation during construction phase.

4-3. Establish procedures and R&R for all stakeholders

When project participants are selected, overall project organizational structure and the roles and responsibility for the project tasks must be appropriate to the characteristic of the organization. By providing each organization with the appropriate tasks and authorization by the owner, unnecessary and repetitive tasks can be decreased and effective operation of the organization will be possible. Especially, leadership must be authorized to the PM/CM, who represents and performs the tasks in lieu of the owner, for a successful project management.

CSF 5. Capability of project stakeholders: Acquiring stakeholders capable of maximizing skills in the right time

The Project must be carried out according to the detailed plan that was developed in order to achieve the specific vision and goals established for the project success. The owner and the various project participants, are responsible in performing such tasks. In the end, the success of a project lies on each competent participant who skillfully performs his tasks.

5-1. Project manager's leadership and skills

The Project Manager and the PM company as the representative of the owner have a significant impact on project success. Therefore, the project manager has a very important role that will determine the success of a project through his leadership and role in the project. It is necessary early in the project to check whether the leadership and skills of the project manager can lead the project to achieving the project goals.

5-2. Architect's capability in design and project execution

The key to construction management is design management (DM), and its importance accounts for 80% of the CM. Design review, a similar concept of DM, but with fundamentally different goals. Design review is the action of reviewing the design. Although the aesthetics of the design or the functional aspect of the design is reviewed as well, usually the discrepancies within the design are reviewed and evaluated. Identifying issues with the design, reviewing and suggesting improvements for the coordination and clashes between the structure, finishes, electrical, mechanical, and plumbing work to increase the quality of the design are the predominant tasks. DM refers to the task of constantly managing and reviewing cost and schedule, and other management factors as the design progresses and adapting the design in order to achieve the owner's requirements and the project goal.

<u>CSF 6. Team Building (team work): Establishing trust through definite communication between participants</u>

Team building (team work) is the process of developing responsibility, trust and dedication, interdependency, common goals among the project team members, and to enhance the problem solving skills between the team members. The key factor to the team building process is having trust in one another, sharing common project goals, developing interdependence between team members, and so forth. This is a short-term process that is established for a specific project. For team building, project participants must share the roles and responsibility of their individual tasks, and therefore, the roles must be established specifically for each team member. Also opinions must be shared through open communication and feedback, and satisfaction on tasks needs to be established based on a positive attitude. Then project performance can be enhanced through such team building. More specifically, identifying issues early, enhancing organization internal/external relationships, decreasing hostile relationships, establishing trust and developing a team mind, the practice of open communication, enhancing collaboration/cohesiveness/problem solving skills thereby enhancing project quality throughout the project phase after.

6-1. Establish trust between project participants and active communication

Project participants constantly collaborate throughout the project. In order to strengthen such teamwork, there must be trust between each other and a system where open communication is possible must be established. Building trust between project participants depends on the project philosophy, degree of ethics, sense of common responsibility, identifying solutions to issues with all participants, and acting on what is promised. An ecosystem where every partner trusts another must be established to create a win-win situation.

6-2. Early integration (IPD) of design and construction

For effective team building, project participants with common tasks must share their roles and responsibilities with other participants. Responsibility for collaboration as a team member must be clearly defined. Implementing IPD (integrated project delivery) method is an innovative contracting method that requires the owners will or understanding. How much each participant understands its roles and responsibility for every project depends on how well the common project goal is shared realistic tasks and defined goals are set.

6-3. Integration of partnering

Open communication and a collaborative environment between project participants enhances the cohesiveness and problem solving skills of the project organization. It is an important factor in enhancing the overall quality of the project. Partnering takes a big role in activating it. How well project participants communicate and collaborate by implementing partnering depends on the understanding of the partnering goals, how fair and logical the task process is, and the skill to achieve an understanding through negotiation.

6-4. Smooth communication and cooperation between participants

An important factor in team building is to establish a strategy for communication between project stakeholders, and a system to operate it. It provides motivation for project participants to effectively develop team building, and actively seeks stakeholders to participate in the project. For large projects, the owner needs the management, representative, and working team to communicate with each other, and the construction participants, PM/CM, designer, constructor, and specialized contractors, need to communicate with each other. Relationship with the public, press, and related organizations with the project is also important.

SECTION Ⅲ – SYSTEM

CSF 7. Process: Enhancing interrelationship between construction life-cycle

Project follows the process that was developed in the execution plan. By mitigating and taking action on the risks for each project phase and performing tasks according to the systematic process for each phase, the project will be carried out according to the schedule without major problems.

7-1. Risk management by identifying and eliminating risks per project phase

Eliminating the potential risks of a project through risk management will decrease uncertainty and minimize loss. Risk management is essential to handle the risks in advance and ensure the project can proceed safely. Not only should the internal risks, such as cost/schedule/quality/safety/cash flow, be considered but also any external environment risks, such as economic and industrial changes, that are difficult to predict. Furthermore, risks concerning complaints, the media and other related organizations must be managed with the same importance.

7-2. Establishing management process per project phase

A Project is composed of planning, design, construction, and operation and maintenance phase, and each phase has different management points. In particular the design and construction phases involve actually creating the project product, and therefore, the success of the project depends on these two phases. Therefore, establishing a systematic management process for both design and construction phase will have an important influence on the project outcome. Management points and processes for each stage during preconstruction must be developed as suggested by CMAA.

7-3. Establish design management system

The Design Management is performing project management through design. The scope of DM includes design review as well as, but not limited to, cost management, schedule management, quality management, safety management, constructability review, value engineering, project management, and construction administration. In other words, it is a task to achieve the project goal and owner's requirement. Cost, schedule, and all management factors are reviewed as design processes, which are then incorporated into the design. Therefore, the design management task is the key PCA and has a significant influence on the project success.

7-4. Establish dispute resolution procedure (contract/dispute/claim management)

Uncertainty factors such as disputes and claims are inherent within the process of a construction project. Therefore, a systematic procedure in resolving disputes must be established to identify any potential issues in advance and prepare measures to reduce or prevent damage due to disputes. In particular design changes have the highest possibility of disputes, so they must be recorded and managed systematically, and should there be a dispute - prompt response and mitigation actions should be taken in order to minimize any effect on the project.

<u>CSF 8. Tool & Technique: Utilizing superior tools and techniques for smooth performance</u>

The ultimate goal of managing a construction project is to lead the project to success by making sure the project is on time, budget, and within quality specifications through planning and managing the project. In order to do so, it is important to systematically manage the various management points for each project phase. Among which, design management, cost management, claim management, construction management, and change management are especially more important management factors that can lead the project to success.

8-1. Implement cost and schedule management tool for each phase

It is imperative to systematically manage cost and schedule for each project phase in order to efficiently distribute all the resources so that the project goals (quality, cost, schedule, etc.) can be successfully achieved. Systematic management of cost and schedule can be determined by implementing a cost management procedure that will help establish a plan, monitor, analyze, and estimate, and a schedule management tool.

8-2. Implement PMIS and BIM tool

Since the construction phase is realizing the conceptual information portrayed in the design drawings, once the product has been constructed it would become costly and time consuming to go back. Therefore, a systematic management system is necessary to prevent such drastic changes. PMIS is a representative project management information system, and its use has increased due to the efficiency of 3D drawings through BIM. Implementation of PMIS and BIM tool enhances collaboration between construction stakeholders and increases communication which has a significant role in project success. To achieve this, it is necessary to implement it early in the project phase.

CSF 9. Measurement & Evaluation: Continuous feedback on performance through measurement and evaluation

Continuous monitoring of the various management points for each project phase is necessary to determine whether the project is being performed as planned. By continuously measuring and evaluating the progress of the project, it is possible to determine if the established plans can be met and necessary confirmation can be provided.

9-1. Periodic monitoring of management points per project phase

Project success can be measured through the quantitative performance such as schedule, cost, quality, and safety. Such factors must be monitored and managed throughout the project lifecycle. If necessary, an evaluation form should be utilized to systematically management the factors. Monitoring the various management factors for each project phase can be done by applying the monitoring procedure for each project phase, and utilizing the evaluation form tool for each management factors.

9-2. Establish review system for each PCA phase

A review system during preconstruction phase is to review the possible issues that may arise during the construction phase in order to decrease design errors and increase the constructability. Systematic management during the preconstruction phase will achieve a competitive design and enhanced efficiency in project management.

9-3. Constant measurement and evaluation of performance by implementation of project performance management system

In order to measure and evaluate project performance, a tool that can measure and estimate the performance based on the project monitoring results is needed. If possible, objective judgement through quantitative evaluation of performance is needed. Also, by appropriately compensating the participants for performance factors can provide motivation. Continuous measurement and evaluation of project performance can be executed by utilizing a performance measurement tool, evaluating quantitative performance, and compensating the performance.

Appendix 2: PDRI Evaluation Form Utilized for PCA Evaluation form

Weighted Project Score Sheet

SECTION I - BASIS OF PROJECT DECISION							
CATEGORY	Definition Level						
Element	0	1	2	3	4	5	Score
A. BUSINESS STRATEGY (Maximum Score = 214)							
A1. Building Use	0	1	12	23	33	44	
A2. Business Justification	0	1	8	14	21	27	
A3. Business Plan	0	2	8	14	20	26	
A4. Economic Analysis	0	2	6	11	16	21	
A5. Facility Requirements	0	2	9	16	23	31	
A6. Future Expansion/Alteration Considerations	0	1	7	12	17	22	
A7. Site Selection Considerations	0	1	8	15	21	28	
A8. Project Objectives Statement	0	1	4	8	11	15	
						CATEGORY A TOTAL	
B. OWNER PHILOSOPHIES (Maximum Score = 68)							
B1. Reliability Philosophy	0	1	5	10	14	18	
B2. Maintenance Philosophy	0	1	5	9	12	16	
B3. Operating Philosophy	0	1	5	8	12	15	
B4. Design Philosophy	0	1	6	10	14	19	
						CATEGORY B TOTAL	
C. PROJECT REQUIREMENTS (Maximum Score = 131)							
C1. Value Analysis Process	0	1	6	10	14	19	
C2. Project Design Criteria	0	1	7	13	18	24	
C3. Evaluation of Existing Facilities	0	2	7	13	19	24	
C4. Scope of Work Overview	0	1	5	9	13	17	
C5. Project Schedule	0	2	6	11	15	20	
C6. Project Cost Estimate	0	2	8	15	21	27	
						CATEGORY C TOTAL	
Section I Maximum Score = 413						**SECTION I TOTAL**	

Definition Levels

0 = Not Applicable
1 = Complete Definition
2 = Minor Deficiencies
3 = Some Deficiencies
4 = Major Deficiencies
5 = Incomplete or Poor Definition

Appendix 3: Projects Information

Note: Project type and number of floors for the 65 projects utilized in Chapter 5 is shown in the chart below.

#	Type	Project	Super	Base	Total Floors
1	Mixed use	DSH	80	5	85
2	Mixed use	HDS	72	6	78
3	Mixed use	HSD	66	4	70
4	Mixed use	PSS	60	5	65
5	Mixed use	SDO	60	5	65
6	Mixed use	SDI	63	2	65
7	Mixed use	STL	58	5	63
8	Mixed use	DGS	54	7	61
9	Complex	DSS	51	8	59
10	Mixed use	PLC	55	1	56
11	Mixed use	WBC	51	5	56
12	Mixed use	ICY	51	3	54
13	Mixed use	BSN	43	7	50
14	Mixed use	SDD	47	2	49
15	Office	YID	36	7	43
16	Office	STW	32	8	40
17	Mixed use	SCJ	32	7	39
18	Office	BDN	28	7	35
19	Office	RFF	27	5	32
20	Office	SSJ	27	5	32
21	Office	SOD	23	7	30
22	Office	SCB	27	1	28
23	Complex	DGE	25	2	27
24	Office	KBK	20	5	25
25	Office	SAI	20	4	24
26	Office	SHI	19	5	24
27	Office	YHN	17	4	21
28	Office	AJJ	14	7	21
29	Office	LGL	14	5	19
30	Office	GNO	14	5	19

31	Office	SCD	14	4	18
32	Office	SSD	15	3	18
33	Office	PSC	16	1	17
34	Office	WLG	13	4	17
35	Office	KOC	15	2	17
36	Office	SDA	14	3	17
37	Office	AEC	14	3	17
38	Office	NSP	10	5	15
39	Office	YSD	11	4	15
40	Office	KKS	12	2	14
41	Office	SKK	10	4	14
42	Office	TLI	10	4	14
43	Office	ACS	10	4	14
44	Office	SCD	11	3	14
45	Office	LGG	13	1	14
46	Office	KKK	12	1	13
47	Office	PKS	9	4	13
48	Office	PKI	10	3	13
49	Office	PKD	10	3	13
50	Office	SNS	9	2	11
51	Office	KKS	10	1	11
52	Office	DCP	6	5	11
53	Office	SST	6	4	10
54	Office	NCJ	9	1	10
55	Office	SSD	6	3	9
56	Office	LGP	5	4	9
57	Office	ASM	7	1	8
58	Office	MJD	5	2	7
59	Office	KDI	6	1	7
60	Office	CGE	5	2	7
61	Office	GMW	6	1	7
62	Office	DAR	5	1	6
63	Office	SCL	4	2	6
64	Office	YIS	3	1	4
65	Office	DAC	2	1	3

Appendix 4: Survey Form

Customer survey by H-Company was performed every half year from 2007 to 2015, and the survey questions and period are shown in the tables below. Customer satisfaction (KS-SQI) was implemented in 2012 and performed every half year. Between 2007 and 2011, H-Company developed its own customer satisfaction survey questionnaire to evaluate customer satisfaction level. However, in order to compare its satisfaction level with other industries, a standardized model was necessary. Therefore, the KS-SQI model was implemented from 2012 and has been surveying customer satisfaction ever since. As the NPS questionnaire follows the NPS methodology, it was not altered through NPS data ranging from 2007 to 2015. The company name and organization initiating the survey is undisclosed in this research paper.

1) Customer Satisfaction (KS-SQI), NPS Survey Question and Period utilized for this Research

<table>
<tr><th>Type</th><th>Section</th><th>Constructs</th><th>Question</th><th>Period</th></tr>
<tr><td rowspan="7">Customer Satisfaction</td><td rowspan="2">Performance Satisfaction</td><td>Primary Needs Fulfillment</td><td>1-1, 1-2, 1-3</td><td rowspan="7">2012~ 2015</td></tr>
<tr><td>Unexpected Benefits</td><td>2-1, 2-2</td></tr>
<tr><td rowspan="5">Process Satisfaction</td><td>Reliability</td><td>3-1, 3-2, 3-3</td></tr>
<tr><td>Individual Empathy</td><td>4-1, 4-2, 4-3</td></tr>
<tr><td>Positive Assistance</td><td>5-1, 5-2, 5-3, 5-4</td></tr>
<tr><td>Accessibility</td><td>6-1, 6-2</td></tr>
<tr><td>Physical Environment</td><td>7-1, 7-2</td></tr>
<tr><td>NPS</td><td colspan="2">Referral intention</td><td>10</td><td>2007~ 2015</td></tr>
</table>

H-Company Service Quality Evaluation Survey

Dear Customer,

--- is conducting a survey to gather customer's opinion on the project service quality carried out by H-Company. The purpose of the survey is to enhance the quality of H-Company's CM service, and provide a better service in the future.

Thank you for your cooperation and your participation.

April, 2015

SQ1. Which type of work are you responsible of?
① Management ② Technical (architecture/civil/mechanical/electrical/others)

SQ2. How many projects have you participated with H-Company including the previous projects?
① First ② 2~3times ③ more than 4 times

SQ3. Based on your answer on SQ2, about how much time, in total, have you transacted with H-Company?
① Less than 6 months ② 6 months ~2 years ③ more than 2 years

CM Service of H-Company

1. The following questions concern whether your initial goals of have been accomplished while utilizing the services of H-Company

Question	Not at all likely Neutral Extremely likely
1-1. H-Company provided the services as requested by the customer	1-----2-----3-----4-----5-----6-----7-----8----9
1-2. Services provided by H-Company is customer oriented	1-----2-----3-----4-----5-----6-----7-----8----9
1-3. I have achieved my goals by using H-Company's service	1-----2-----3-----4-----5-----6-----7-----8----9

2. The following questions concern unexpected services or differentiated services provided by H-Company.

Question	Not at all likely Neutral Extremely likely
2-1. H-Company provides differentiated services that are not provided by any other CM companies.	1-----2-----3-----4-----5-----6-----7-----8----9
2-2. H-Company provides additional services not included in the contract	1-----2-----3-----4-----5-----6-----7-----8----9

3. The following questions concern how much you trust H-Company and its employees

Question	Not at all likely Neutral Extremely likely
3-1. H-Company employees have the necessary knowledge and skills	1-----2-----3-----4-----5-----6-----7-----8----9
3-2. H-Company abides strictly to the tasks and services mentioned in the contract.	1-----2-----3-----4-----5-----6-----7-----8----9
3-3. H-Company employees managed the project in a fair and transparent method	1-----2-----3-----4-----5-----6-----7-----8----9

4. The following questions concern the customer friendliness of H-Company employees.

Question	Not at all likely Neutral Extremely likely
4-1. H-Company employees explain project-related issues in an understandable context	1-----2-----3-----4-----5-----6-----7-----8----9
4-2. H-Company employees are friendly and appropriate to customers	1-----2-----3-----4-----5-----6-----7-----8----9
4-3. Each H-Company employees show interest in every individual client	1-----2-----3-----4-----5-----6-----7-----8----9

5. The following questions concern how prompt and active services were provided by H-Company employees

Question	Not at all likely Neutral Extremely likely
5-1. H-Company employees acted promptly to the customer's request	1-----2-----3-----4-----5-----6-----7-----8----9
5-2. H-Company employees showed voluntary determination in helping the customer	1-----2-----3-----4-----5-----6-----7-----8----9
5-3. H-Company employees provided accurate and appropriate information concerning the project process and inquiries by the customer.	1-----2-----3-----4-----5-----6-----7-----8----9
5-4. H-Company employees handle the complaints or issues of the customer well.	1-----2-----3-----4-----5-----6-----7-----8----9

6. The following questions concern the accessibility of H-Company services.

Question	Not at all likely Neutral Extremely likely
6-1. It is easy to meet the responsible employee of H-Company when necessary	1-----2-----3-----4-----5-----6-----7-----8----9
6-2. It is easy to inquire or consult the responsible employee of H-Company via phone or email.	1-----2-----3-----4-----5-----6-----7-----8----9

7. The following question concerns the various physical facility and environment of H-Company

Question	Not at all likely Neutral Extremely likely
7-1. Appearance and outfit of H-Company employees neat	1-----2-----3-----4-----5-----6-----7-----8----9
7-2. H-Company office/meeting room facility is clean and pleasant	1-----2-----3-----4-----5-----6-----7-----8----9

8. How much are you willing to recommend the CM services by H-Company to your friends or coworkers? Please select a number that is the closest to what you believe.

Not at all likely					Neutral					Extremely Likely
0	1	2	3	4	5	6	7	8	9	10

8-1. What must be improved first in order to receive a 10 in Question 8?

Appendix 5: Trend Analysis of Referral Intention and Customer Satisfaction

1) Trend Analysis for Projects with More than 10% of Preconstruction Period and Referral Intention and Customer Satisfaction

PCA	Case	Type	Preconstruction Phase				Construction Phase						Pattern
More than 30%s	Case 1	Referral intention	9	7	10	10	10	10	10	10			A
		Customer satisfaction					100	98.8	100	98.8			
	Case 2	Referral intention		8	9	8	10	10	10				B
		Customer satisfaction					96.9						
	Case 3	Referral intention				10	10	10	10	10	10	10	A
		Customer satisfaction					98.3	95.5	95.6	99.4	95.8	99.3	
	Case 4	Referral intention				10	10	10	10	10	10	10	A
		Customer satisfaction					98.3	100	98.3	94.3	100	96.0	
	Case 5	Referral intention				10	9	10	10				A
		Customer satisfaction				98.8	96.9	100	98.1				
	Case 6	Referral intention				8	10	10	10				B
		Customer satisfaction				81.2	100	100	100				
	Case 7	Referral intention			10	5	6	10	10	10	10	10	A
		Customer satisfaction					65.8	93.1	100	100	98.8	98.8	
	Case 8	Referral intention	6	5	8	7	7	3	7				B
		Customer satisfaction					69.3	49.3	73.2				
	Case 9	Referral intention	7	8	8	8	8	9					B
		Customer satisfaction					82.3	72.3					
	Case 10	Referral intention			8	7	7	8	9	9	10		B
		Customer satisfaction					91.1	89.7	96.9				
	Case 11	Referral intention			9	10	10	10	10	10			A
		Customer satisfaction				100	97.3	99.2	99.4	99.1			
	Case 12	Referral intention			10	10	10	10	10	10			A
		Customer satisfaction				100	97.3	99.2	99.4	99.1			
	Case 13	Referral intention			9	10	10	6	10				A
		Customer satisfaction				96.8	86.5	63.7	97.9				
	Case 14	Referral intention			9	10	8	9	6				C
		Customer satisfaction							75.3				
	Case 15	Referral intention				2	8	10	2	10			B
		Customer satisfaction					92.7	100	52.5	100			
	Case 16	Referral intention				10	10	9	10	9			A
		Customer satisfaction					97.3	100	93.0	93.0			

2) Trend Analysis for Projects with 10~30% of Preconstruction Period and Referral Intention and Customer Satisfaction

PCA	Case	Type	Preconstruction Phase			Construction Phase						Pattern
10~30 %	Case 17	Referral intention			10	10	10	9	9			A
		Customer satisfaction				89.1	97.3	89.5	89.7			
	Case 18	Referral intention			9	10	10	9	8			C
		Customer satisfaction				90.0	100	90.7	82.2			
	Case 19	Referral intention	8	7	7	10	9					B
		Customer satisfaction					96.4					
	Case 20	Referral intention			5	9	10	10				B
		Customer satisfaction					100	100				
	Case 21	Referral intention			10	9	7	9	5	10		A
		Customer satisfaction										
	Case 22	Referral intention			9	10	10	9	7			C
		Customer satisfaction						90.4	98.4			
	Case 23	Referral intention			10	10	10	10				A
		Customer satisfaction						90.5				
	Case 24	Referral intention	10	9	10	10	10	10	10	10		A
		Customer satisfaction								100		
	Case 25	Referral intention			10	9	9	10	10	10		A
		Customer satisfaction								98.4		
	Case 26	Referral intention			10	10	10	10				A
		Customer satisfaction			96.7	100	100	97.4				
	Case 27	Referral intention		10	10	10	10	10				A
		Customer satisfaction						86.4				
	Case 28	Referral intention		10	9	9	10	10	10	5	5	C
		Customer satisfaction										
	Case 29	Referral intention			6	5	8	5				A
		Customer satisfaction										

3) Trend Analysis for Projects with Less than 10% of Preconstruction Period and Referral Intention and Customer Satisfaction

PCA	Case	PCA Performance	Construction Phase						Pattern
Less than 10%	Case 30	Referral intention	10	10	10	10			A
		Customer satisfaction	100	100	100	100			
	Case 31	Referral intention	9	9	9	5			C
		Customer satisfaction	82.6	95.1	69.8	41.6			
	Case 32	Referral intention	10	5					C
		Customer satisfaction	100	30.7					
	Case 33	Referral intention	8	10	10				B
		Customer satisfaction			99.0				
	Case 34	Referral intention	5	9	8	10			B
	Case 35	Referral intention	8	8	9	8			A
	Case 36	Referral intention	9	8	10				A
	Case 37	Referral intention	9	9					A
	Case 38	Referral intention	9	9	10	10	10	6	C
	Case 39	Referral intention	9	8	8				C
	Case 40	Referral intention	9	10	9				A
	Case 41	Referral intention	7	6	9	10			B
	Case 42	Referral intention	9	9					A
	Case 43	Referral intention	10	8	9				A
	Case 44	Referral intention	9	9					A
	Case 45	Referral intention	9	9	9				A
	Case 46	Referral intention	9	7					C
	Case 47	Referral intention	9	7					C
	Case 48	Referral intention	8	8					A
	Case 49	Referral intention	10	10					A
	Case 50	Referral intention	10	5	9	10	10	10	A

Note. Referral intention and customer satisfaction (KS-SQI) trend analysis was divided into preconstruction and construction phase. Survey results for both referral intention and customer satisfaction is shown. Since preconstruction and construction duration for each project differs, the number of surveys performed differs but it was performed every half year. Raw data from NPS was used for referral intention and customer satisfaction was converted into 100 points for this research.