PERFORMANCE EVALUATION OF ENGINEERING, PROCUREMENT AND CONSTRUCTION PROJECTS USING PERFORMANCE PRISM

PROJECT REPORT

Submitted by

VANI MOHAN V.

TKM20CESC17

to

the A P J Abdul Kalam Technological University

in partial fulfilment of the requirements for the award of the Degree

of

Master of Technology

In

Structural Engineering and Construction Management

DEPARTMENT OF CIVIL ENGINEERING

TKM College of Engineering, Kollam

July 2022

DECLARATION

I undersigned hereby declare that the project report, “Performance Evaluation of Engineering, Procurement and Construction Projects using Performance Prism”, submitted for partial fulfilment of the requirements for the award of the degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Dr. Anu V. Thomas. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and/ or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Place: Kollam

Date: 07/07/2022 Vani Mohan V.

DEPARTMENT OF CIVIL ENGINEERING

TKM COLLEGE OF ENGINEERING, KOLLAM

CERTIFICATE

Certified that this report entitled '**PERFORMANCE EVALUATION OF ENGINEERING, PROCUREMENT AND CONSTRUCTION PROJECTS USING PERFORMANCE PRISM**' is the report of project presented by **VANI MOHAN V, TKM20CESC17** during **2021-2022** in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering and Construction Management of the A P J Abdul Kalam Technological University.

Guide	Coordinator	Head of the Department
Dr. Anu V. Thomas	**Dr. Ramaswamy K. P.**	**Dr. Sajeeb R.**
Professor	Assistant Professor	Professor
Dept. of Civil Engg.	Dept. of Civil Engg.	Dept. of Civil Engg.
TKMCE, Kollam	TKMCE, Kollam	TKMCE, Kollam

ACKNOWLEDGEMENT

First of all, I take this opportunity to express my sincere gratitude to my guide Dr. **Anu V. Thomas**, whose timely support; positive criticism and guidance helped me throughout for the preparation and completion of this project work.

I extend my sincere thanks to the project coordinator **Dr. Ramaswamy K. P.** for his on-time positive criticisms and suggestions which helped in the successful completion of this work.

I would also like to extend my gratitude to the Head of the Department, **Dr. Sajeeb R.** for the valuable support and suggestions he has provided throughout the work.

I am sincerely thankful to various industry professionals who had helped me by giving valuable suggestions and also by taking part in the questionnaire surveys.

Finally, it is my pleasure to take this opportunity to thank all the others who have played a vital role in providing intellectual and material support very cooperatively.

Vani Mohan V.

ABSTRACT

Over the past few decades, the complex global business environment and increasing business competitiveness have highlighted the importance of performance evaluation in the construction industry which has long been criticized for its underperformance. Performance evaluation is the process of quantifying the efficiency and effectiveness of past actions, and a performance measure is a parameter used to quantify the efficiency and/or effectiveness of past actions. With the development of performance measurement in the construction industry over the past decades, the performance evaluation has extended to the organizational level and the project stakeholder level from just being concentrated on the project budget and schedule alone.

Engineering, Procurement and Construction (EPC) projects are one such kind of construction projects that require careful evaluation of its performance throughout and hence this research was carried out to identify the performance indicators of EPC projects in Kerala, which were then prioritized using Analytical Hierarchy Process (AHP) for important stakeholder categories of EPC project. Out of all indicators client's satisfaction, contractor's and supplier's overall performance, experience of the client and contractor, user's satisfaction, performance of the infrastructure, value for money, project profitability and appropriateness of the project size and location were the most important ones.

An EPC project in Kerala was selected to conduct its performance evaluation. The indicators in the project were ranked using RII and compared with the AHP results for different stakeholder categories. Performance Prism framework, which is a holistic framework that evaluates different stakeholder perceptions of the project was then used to determine the performance efficiency of the EPC project in Kerala. This study can act as a base for the use of the Performance Prism framework in EPC project performance evaluation.

Keywords: Performance evaluation, Engineering, Procurement and Construction (EPC), Performance Prism, Analytical Hierarchy Process (AHP), Relative Importance Index (RII)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AHP	Analytical Hierarchy Process
BOT	Build-Operate-Transfer
BSC	Balanced Scorecard
CSF	Critical Success Factor
DB	Design-Build
DBB	Design-Bid-Build
EFQM	European Foundation for Quality Management
EPC	Engineering, Procurement and Construction
EVM	Earned Value Management
GDP	Gross Domestic Product
IR	Relative Importance Index under Importance Rating
KPI	Key Performance Indicator
NH	National Highway
NHDP	National Highway Development Project
PI	Performance Index
PR	Relative Importance Index under Prevalence Rating
PPP	Public-Private Partnership
RII	Relative Importance Index
TCQ	Time, cost and quality

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

The construction industry plays an important role in the economic and infrastructural development of a country. In India, the construction industry is considered one of the most important industries as it contributes to 8% of the country's Gross Domestic Product (GDP), making this industry the second largest employer in the country (Prasad et al., 2018). Every construction project is unique and complex and hence requires careful supervision. The most frequent problem that usually arises within the construction projects is budget or schedule overruns. Budget and schedule overruns in large construction projects can bring out huge crisis in the economic sector of the country. Construction projects largely need new techniques through which these projects can be continuously monitored and delivered on time and within the budget.

Project performance evaluation mainly deals with measuring the efficiency and effectiveness of activities in a project and monitoring its progress over time. It helps to identify whether the prior assumptions and constraints regarding the project are still reliable or not. If they are found not reliable, then remedial measures can be taken appropriately thereby making a chance for the project to become a success. It can be used to study the transparency and accountability of the project and also allows sharing the knowledge and expertise gained through the process within the team (Haass and Guzman, 2019). The basic procedure for project performance evaluation involves finding answers to the following questions:

- What all measures are to be evaluated?
- How to plan the evaluation process?
- Which tools and methods are to be used in the process?
- How to interpret the results?

Traditional projects were evaluated based on the budget and schedule constraints alone. Those evaluation frameworks were designed to check whether there occurred any budget or cost overruns in the project. Even with the presence of these

performance evaluation methods, the construction projects are susceptible to failures occurring due to these constraints. It shows that there lacks a properly framed performance evaluation technique that can bring change to the whole working mechanism of the project instead of concentrating only on the budget and schedule constraints and also allows to correct the defects occurring during construction at that right time. Newly emerging performance evaluation models use various other parameters as the basis for evaluation like stakeholder satisfaction, business growth and health and safety considerations. By taking such parameters as the basis for evaluation, the projects can be monitored even during construction and some problems can be eliminated even before they occur (Wadugodapitiya et al., 2010).

1.2 ENGINEERING, PROCUREMENT AND CONSTRUCTION (EPC) PROJECTS

EPC is a type of construction contract that emerged in the United States in the 1970s in which an EPC contractor arranged by the client holds the responsibility for the design, procurement, construction as per the client's required specifications and handing over of the project for a pre - fixed budget and schedule. Failing to deliver the project on the fixed date of completion or for a fixed budget makes the EPC contractor to bear the liability. As explained by Solabannavar and Jamadar (2017), some of the key features of the EPC model are:

- The client has to engage only with the EPC contractor
- The EPC contractor must deal with the rest of the personnel like sub – contractors, labourers and so on and must take most of the final decisions related to project execution
- All the risks related to the project execution can be transferred to the EPC contractor from the client
- The client has to put minimum effort and less strain in the project but on the other side, they have only limited participation and control over the project

Despite the application of EPC model over the other project delivery models like BOT, the construction industry is still suffering from inefficiency in terms of time and cost overruns and poor quality, which can threaten the entire life of the projects and lead to delays, disputes, and losses to all the stakeholders involved. In general, the average magnitude of cost and time overrun in the construction industry depends on

various project characteristics that comprise project location, project type, industry, and time of construction. Since the contractors work under limited time and budget and also solely bear the risks related to the project, it may lead to cost overrun or schedule overrun at times (Habibi et al., 2019). Appropriate and timely evaluation of the progress of the construction projects carried out by the contractor can bring out a huge change in the end results of that project and also to the upcoming projects as well. Continuous monitoring of project results is possible by properly evaluating project performance at regular intervals and its deviations from pre-defined objectives can be rectified through proper remedial measures.

This thesis aims to identify the performance indicators of EPC projects in Kerala and to evaluate the performance of EPC projects using the Performance Prism method which is a multi-dimensional approach that helps in monitoring not only the project cost but also analyses the project from an overall point of view. Analytical Hierarchy Process (AHP) is also used in the study to prioritize the performance indicators.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study are mentioned below:

1) To identify the project performance indicators for the performance evaluation of EPC projects in Kerala
2) To prioritize the performance indicators using Analytical Hierarchy Process (AHP) for various stakeholders
3) To rank the performance indicators in an EPC project in Kerala and compare it with AHP results
4) To evaluate the performance of the EPC project in Kerala using the Performance Prism framework

1.4 SCOPE OF THE STUDY

- The study is limited to the performance evaluation of construction projects delivered through EPC mode
- Analytical Hierarchy Process (AHP) is used for the prioritization of performance indicators
- Performance evaluation of a single highway project in Kerala is conducted in this study using the Performance Prism framework

1.5 ORGANIZATION OF THE THESIS

The study is described in seven chapters as given below:

The general introduction to the study including performance evaluation and EPC projects are explained in Chapter 1 along with the objectives and scope of the study.

Chapter 2 provides a brief review of the literature that was referred for the preparation of this work.

Chapter 3 gives the detailed research methodology of this study along with a brief introduction to the related analysis tools and techniques.

The idea behind the Performance Prism framework and the detailed classification of the indicators for evaluation is explained in Chapter 4.

In chapter 5, a brief introduction about AHP analysis is given and the results of the prioritization of performance indicators using AHP is also provided.

Chapter 6 deals with the implementation of performance evaluation of an EPC project in Kerala using the Performance Prism framework. A comparison of the ranking of indicators obtained using AHP analysis in chapter 5 with the ranking of indicators determined using Relative Importance Index analysis for the EPC project is also explained in this chapter.

Chapter 7 is the final chapter in the study which summarizes the work done and draws conclusions from the results.

CHAPTER 2

LITERATURE REVIEW

2.1 PROJECT PERFORMANCE EVALUATION

Bassioni et al. (2004) discuss about the features and implementation of performance measurement frameworks used in UK construction firms. The dissatisfaction with the traditional financial-based performance measurement systems lead to the origin of other methods such as Balanced Scorecard (BSC), quality-based excellence model like the European Foundation for Quality Management (EFQM). These methods can not only be used for a project-level evaluation but also for an organizational-level performance evaluation. In a similar manner, Lop et al. (2018) conducted a study to find out the strengths and weaknesses of existing performance evaluation techniques in the Malaysian construction industry like BSC, EFQM, Malcolm Baldrige for performance excellence, Performance Prism and Key Performance Indicator (KPI) systems. The authors classified each project evaluation model according to the type of construction projects for which it can be used. Deli et al. (2012) and Liu & Jiang (2019) have also carried out studies related to existing project evaluation models. The former study was based on EFQM model for PPP projects whereas the latter was about the effect of changes in scope and quality on the cost and schedule of the project using Earned Value Method (EVM). Wadugodapitiya et al. (2010) combined AHP analysis with BSC model to formulate a building performance evaluation model. AHP was used to prioritize the indicators which were evaluated using the BSC model.

In developing countries, construction contracts are mostly awarded to the lowest bidder and studies show that this technique will not always guarantee success for the project. Deep et al. (2018) conducted a study to find out the critical factors that affected the performance efficiency of contractors selected through such modes for state funded projects. The consultant's influence was mainly found to be impacting the contractor performance. Critical success factors (CSFs) were also found by El – Abidi et al. (2019) for the smooth implementation of the Industrialized Building System (IBS) in the Malaysian construction industry. 15 CSFs were identified and classified into five categories which were finally prioritized using AHP tool. Thomas

and Thomas (2019) conducted a study to find out the important factors affecting the performance of PPP projects in Kerala. 60 performance indicators were identified and ranked using the Relative Importance Index (RII) method. Selection of right project, users' satisfaction, capability of project team, the necessity for the project and value for money were the most significant critical success factors. Abbasi et al. (2020) determined the root causes of delay in construction projects in the Iran construction sector by representing them in the form of the Ishikawa diagram (fish bone diagram) by dividing them into eight categories. Contractor's financial problem was found as the leading cause of delay and the authors also proposed some solutions for these delays in the paper.

2.2 EPC AND PPP PROJECTS

Solabannavar & Jamadar (2017) explained EPC as a common type of contract suitable for large infrastructure projects in which EPC contractor will design the facility, procure materials and equipment and constructs the facility which will then be returned to the owner. The authors compared PPP and EPC projects by stating their advantages and disadvantages. Leading EPC contractors in India were also mentioned in the paper. The factors that affect the success of EPC projects were also studied by different researchers. Habibi et al. (2018) studied different cost and schedule related performance indicators for EPC projects in a stage-wise manner (engineering stage, procurement stage and construction stage). They found that design changes were the main factor that caused delay and cost overrun in the engineering and construction phase whereas resource shortages delayed the project and price fluctuations increased the project cost in the procurement phase. Change order driven by owner in the engineering stage was proven to be the most important factor in causing schedule and cost overrun in EPC projects by Habibi et al. (2019). The authors studies the impact of each performance indicator in EPC projects by classifying them into the three EPC phases and then prioritizing them using Epsilon-squared effect size technique to find their weight impacts. Some best practices for the construction industry to reduce cost and schedule overrun were also proposed by the authors. Similarly the stage-wise performance indicator classification was also conducted by Kabirifar & Mojtahedi (2019). The indicators were the ranked using TOPSIS method which is a multi-attribute group decision making tool. From the study, engineering design, project

planning and controls are the most significant indicators followed by construction and procurement stage respectively.

Implementation of affordable housing scheme in developing countries through PPP mode and their CSFs were studied by Alteneiji et al. (2020). This study was conducted with an aim to find out the factors that can increase private sector participation in providing housing. 30 CSFs for PPP projects were ranked according to their frequency of occurrence in the past literature in which political support and stability stood first followed by trust and openness among the different stakeholders. Choi et al. (2020) examined and compared the effect of timing of change orders in the cost and schedule performance of Design – Build (DB) and Design – Bid – Build (DBB) projects. As a result, DB projects found to be outperforming DBB projects in terms of schedule but cost performance was almost same for both.

2.3 PERFORMANCE PRISM FRAMEWORK

Neely et al. (2001) introduced Performance Prism framework for the purpose of performance evaluation of projects. The authors elaborate the five facets of the method and its usage in practical situations. The application of this method is not only restricted to the construction industry and therefore case studies which uses performance prism for performance evaluation have been explained in the paper. Performance prism was introduced to replace the quality based excellence model and BSC model as they are vague and does not take into account the important parameters like a wide range of stakeholders and their partnership. Liu et al. (2014) and Liu et al. (2017) examined the usage of Performance Prism method for the ex-ante evaluation of PPP projects. The core performance indicators of PPP projects under each of the five facets were also determined.

2.4 RANKING OF ATTRIBUTES

Saaty (1990) introduced a new technique for decision making using multi-criteria, which is known as the Analytical Hierarchy Process (AHP). This method gives relative priority weights for the analyzing factors and therefore can be used for ranking the indicators for performance measurement. Balubaid & Alamoudi (2015) explained the procedure for AHP analysis through an example in which AHP was used for decision making in contractor selection for a construction project. Relative

Importance Index (RII) method was also one such method used to find out the relative importance of attributes with respect to one another and thereby rank them. Kassem (2020) used RII method in the oil and gas industry of Yemen to rank the risk factors involved in it. The RII under probability and impact of the factors were determined to obtain a balanced result and thereby finding the overall RII of the factors. RII analysis was also explained in detail by Gunduz et al. (2013) as he used this method to rank the delay factors in construction industry in Turkey. A total of nine broad categories of delay factors were subdivided into numerous factors which were ranked using RII. The average of RII values of the delay factors in a category was taken to determine to RII value of that particular broad category.

2.5 SUMMARY OF THE LITERATURES

Performance monitoring or evaluation of large infrastructure projects through PPP and EPC mode has been reviewed. Different evaluation models like BSC, EFQM, Malcolm Baldrige for performance excellence, EVM and Performance Prism were studied in detail. Out of the various frameworks available for performance evaluation of projects, Performance Prism framework was found to be suitable for this study because for projects in which various stakeholders are involved, like EPC projects, this framework can be used to get performance results based on the perception of different stakeholders involved. The techniques that can be used for ranking of the performance indicators were also reviewed. It was seen that AHP and RII analyses would serve the purpose.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 GENERAL

This chapter describes the methodology adopted in this study. The flow diagram of the methodology is given in figure 3.1.

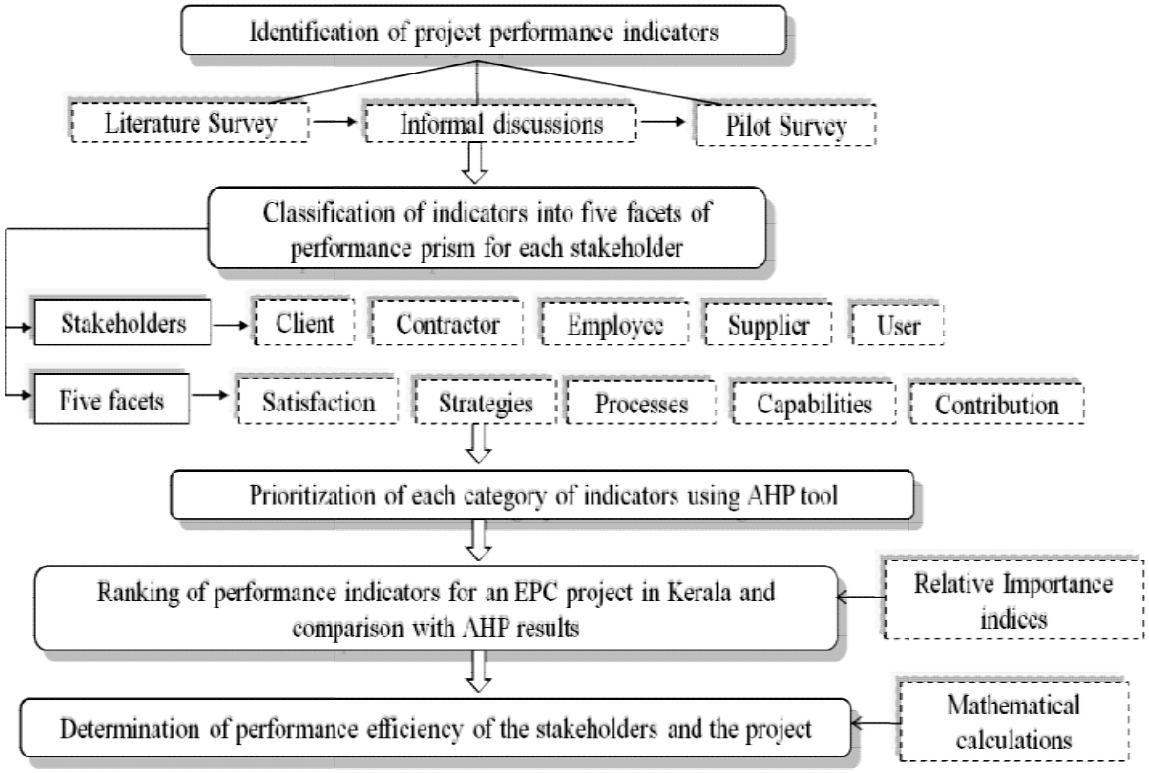

Figure 3.1: Flow diagram of methodology of work

The first step in the research study was to identify the parameters that can act as performance indicators of an EPC project. This was accomplished through an extensive literature review. With the performance indicators obtained from the past literatures, a pilot survey was conducted and only those indicators which were highly significant for EPC projects were selected. The next step was to classify the indicators according to the Performance Prism framework and also to choose the stakeholder categories for evaluation. In this study, five stakeholder categories were chosen for evaluation which include Client (public party), EPC contractor (private party), Employees of the contractor, Material and Equipment Suppliers and the End-users of the constructed facility. The priority weights of the indicators were then found out

using Analytical Hierarchy Process (AHP). For this purpose, five different AHP questionnaires were distributed to each of the chosen stakeholder categories with the indicators classified under that stakeholder category. After AHP analysis, a highway project in Kerala which was constructed through EPC mode was selected and the performance indicators were ranked for the project using Relative Importance Index (RII) method, which were compared with the AHP rankings. Then the performance evaluation of the project was conducted through the Performance Prism framework.

3.2 PROJECT PERFORMANCE INDICATORS

From reviewing the literature on about EPC projects, 58 parameters were identified as influencing the performance of EPC projects. Since performance evaluation with all these 58 indicators was found difficult, a pilot survey was conducted among construction officials with vast experience in working in EPC highway projects. The questionnaire for the pilot survey is attached in Appendix A.

The questionnaire for the pilot survey consisted of three parts:

a) Introduction – In this section, an introduction about the project work and the purpose of the survey was explained.
b) General Information – The information about the respondent was collected in this section which included the name of the organization of the respondent, designation and working experience of the respondent.
c) Performance Indicators of EPC projects – This section included all the 58 performance indicators. The respondents were asked to mark the significance of these indicators on the performance of EPC projects on a 5 point Likert scale in which, 1 represented no significance and 5 represented extremely significant.

From this section, 45 performance indicators with a significant scale rating equal to and more than 3 were selected for the project performance evaluation. The shortlisted performance indicators are shown in Table 3.1. $F_1 – F_5$ in the serial number column represents the five facets of the Performance prism framework into which the indicators are classified. The classification of indicators will be explained in detail in the coming sections.

Table 3.1: 45 EPC project performance indicators

Sl. No.	Performance Indicators
$F_1$1	Client's satisfaction for time, cost & quality
$F_1$2	Contractor's satisfaction for time, cost & quality
$F_1$3	Employee's satisfaction for time, cost & quality
$F_1$4	Supplier's satisfaction for time, cost & quality
$F_1$5	User's satisfaction for time, cost & quality
$F_1$6	Profitability of the project
$F_1$7	Appropriateness of the project size & location
$F_2$8	Performance level of the service provided
$F_2$9	Value for money of the project
$F_2$10	Health, safety & environmental impact of the project
$F_2$11	Technology diffusion in engineering, procurement & construction stages
$F_2$12	Technology diffusion in material supply & management
$F_3$13	Competitiveness & transparency in the procurement process
$F_3$14	Effectiveness in communication and coordination between the stakeholders
$F_3$15	Appropriateness of the contract criteria for the project
$F_3$16	Provision of payments on time for completed work by the client
$F_3$17	Effectiveness of facility maintenance and management
$F_3$18	Efficiency of risk management (identification, analysis & allocation)
$F_3$19	Appropriateness in the budget and schedule estimates
$F_3$20	Extent of site management and supervision
$F_3$21	Claim and dispute management
$F_3$22	Degree of project team work and partnerships
$F_3$23	Transportation of materials and equipments on time
$F_3$24	Appropriateness of supply contract criteria
$F_4$25	Efficient TCQ & material management system
$F_4$26	Favourability and efficiency of the legal framework
$F_4$27	Financial stability of the client
$F_4$28	Prior experience of client & EPC contractor
$F_4$29	Reputable developer / strong and good private consortium
$F_4$30	Presence of skilled working personnel
$F_4$31	Use of advanced planning and scheduling techniques
$F_4$32	Financial stability of the EPC contractor
$F_4$33	Capability for right selection of project teams
$F_4$34	Sufficient availability of good quality construction materials, equipments and skilled labour for the project
$F_4$35	Knowledge about the project for the users
F_5 36	Client's willingness to active participation
$F_5$37	Client's contribution to contractor selection

Sl. No.	Performance Indicators
$F_5$38	Contractor's willingness to active participation
$F_5$39	Contractor's overall performance
$F_5$40	Employee's willingness to active participation
$F_5$41	Employee's overall performance
$F_5$42	Supplier's willingness to active participation
$F_5$43	Supplier's overall performance
$F_5$44	User's willingness to the infrastructure use
$F_5$45	Presence of supporting & understanding community

3.3 PERFORMANCE PRISM FRAMEWORK

Performance prism was the framework chosen for project performance evaluation in this study. This method was chosen because it evaluates a project from the perspectives of different stakeholders involved in it. As per this framework, the performance indicators of a project can be classified into five inter-related facets of measurement which can be explained as (Liu et al., 2017):

- Stakeholder satisfaction – it identifies the key stakeholders of the project and their wants and needs
- Strategies – it decides the strategies that the organization must put in place to satisfy the stakeholder's wants and needs while satisfying its own requirements
- Processes – it identifies the processes that need to be operated in the organizational level to execute the strategies decided
- Capabilities – it evaluates the capabilities needed for the organization for operating the processes
- Stakeholder contribution – it demands the needs and wants of the organization from the stakeholders in return for the successful implementation of the project

In order to evaluate a project using Performance Prism, the indicators must be classified into this framework. In this study, after finalizing the performance indicators, five key stakeholders of EPC projects were chosen. They were clients, EPC contractors, employees, material and equipment suppliers and the end-users. The

indicators are first divided into the five facets of the evaluation framework followed and followed by their division into the five stakeholder categories.

3.4 ANALYTICAL HIERARCHY PROCESS (AHP)

The prioritization of the performance indicators gives their ranking and this can be obtained by using Analytical Hierarchy Process (AHP). After the indicators were classified into the Performance Prism framework, AHP was used to prioritize each indicator and their priority weights with respect to each other were determined. For this purpose, AHP survey was conducted by distributing five different questionnaires to five chosen stakeholder categories.

3.5 PERFORMANCE EVALUATION OF EPC PROJECT

In order to find the actual performance of a construction project using the Performance Prism framework, a highway project in Kerala constructed through EPC mode was selected. The selected project was the Kollam Bypass project. For the evaluation of the project performance, the formulated Performance Prism framework was used which included five stakeholder categories with 45 different performance indicators. Five different questionnaires were distributed to the five stakeholder categories of the project to mark the importance and prevalence of the indicators in that project. Using this, the performance indicators for the project were ranked using their RII values and then the performance of each of the stakeholders and the overall performance of the Kollam Bypass project was obtained.

3.6 SUMMARY

This section explained the detailed methodology for this study which was started with the identification of 45 performance indicators for EPC projects, followed by its classification into the five facets of the Performance Prism framework. The 45 indicators along with its classification into the five facets of the framework are shown in this section. AHP analysis was also included in this study to prioritize the indicators. The implementation of the Performance Prism framework on an EPC project in Kerala was decided to be conducted on Kollam Bypass project. The rankings of the indicators in the project were obtained using RII analysis followed by the performance evaluation of the project.

CHAPTER 4

FORMULATION OF PERFORMANCE EVALUATION MODEL FOR THE PROJECT

4.1 GENERAL

After the project performance indicators were finalized, the next step was to establish an evaluation model using those indicators. Performance Prism framework was chosen for the implementation of performance evaluation in this study. As per this framework, there are five facets for performance evaluation and these indicators were then divided into these five facets for each of the stakeholder categories selected in this study.

4.2 PERFORMANCE PRISM FRAMEWORK

Over the years, the construction industry has been looking for an integrated performance measurement system that incorporates and analyses all the important aspects of a construction project for evaluation. Designing a performance measurement framework to measure business as well as project-related aspects is a complex and challenging task. The industry has seen many evaluation frameworks like Balanced Scorecard model, Quality Based Performance Excellence models, Key Performance indicator model and so on. All these models have advantages of its own but none were evaluates the project in a multiple stakeholder environment.

Performance Prism proposed by Neely et al. (2001) is a holistic framework designed to tackle the complexity of multiple stakeholders in a construction project by considering the stakeholder perception of the project for performance evaluation. This framework consists of five interrelated facets designed for measurement (Neely et al., 2001).

1. Stakeholder satisfaction: who are our stakeholders and what do they want and need?

2. Strategies: what strategies do we need to satisfy these sets of wants and needs while satisfying our own requirements as well?

3. Processes: what processes do we need to allow our strategies to be delivered?

4. Capabilities: what capabilities do we need to put in place to allow us to operate our processes?

5. Stakeholder contribution: what do we want and need from our stakeholders on a reciprocal basis?

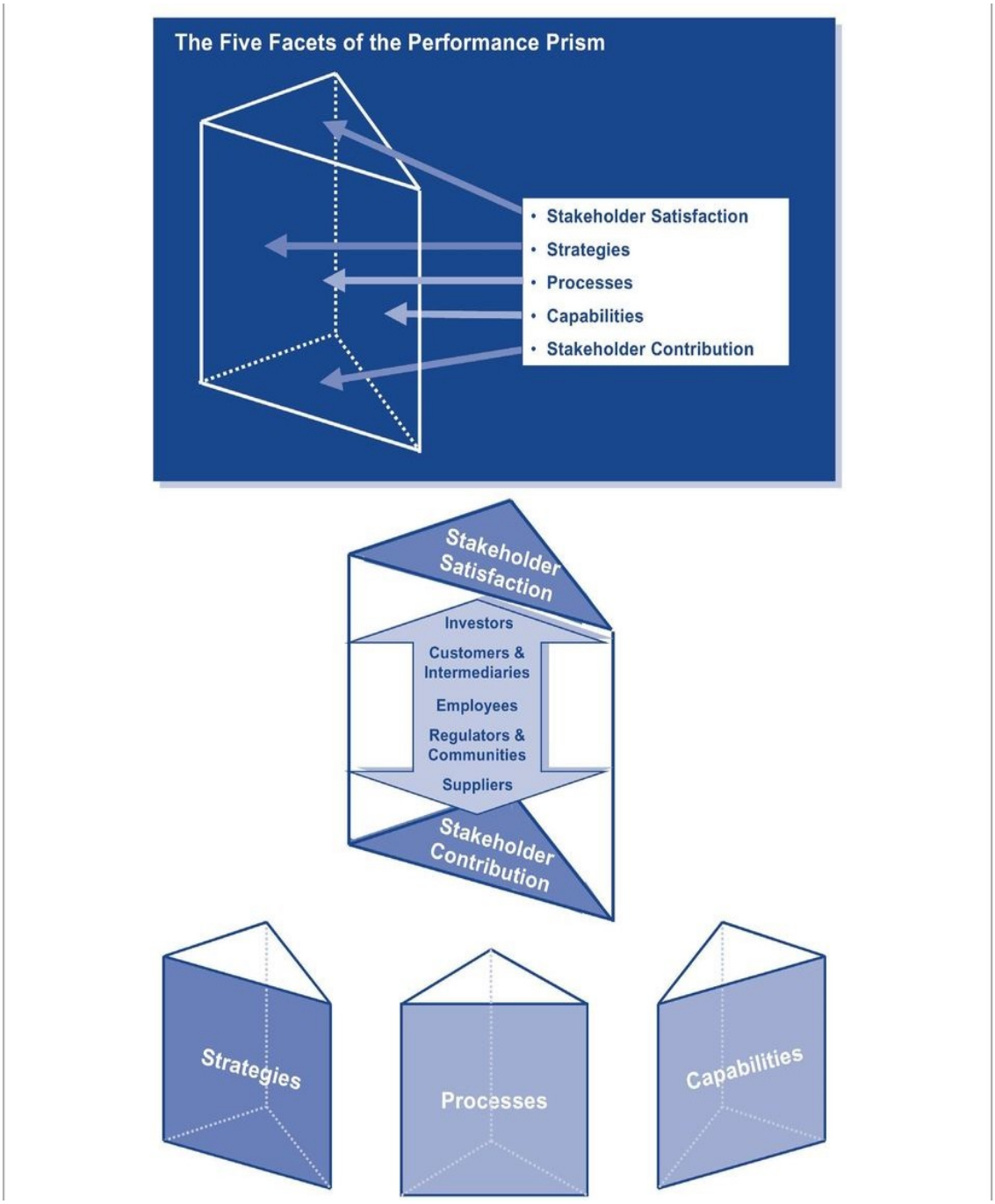

Figure 4.1: Performance Prism model (Neely et al., 2001)

4.2.1 Stakeholder Satisfaction (F_1)

The performance prism commences with the facet of stakeholder satisfaction which introduces the important stakeholders involved in a construction project like contractors, suppliers, employees, customers, investors and so on and explains their needs and wants from it. All other existing performance evaluation frameworks do not mention anything about the stakeholders and their needs and satisfaction, yet they play an important role in the performance of a project. It is designed on the belief that satisfying stakeholders' wants and needs are the most important task for the existence of any organization (Liu et al., 2014; Neely et al., 2001; Neely et al., 2005).

4.2.2 Strategies (F_2)

Strategies play a very crucial role as the foundation for organizational activities as well as the project goals. Without properly planned strategies, it is impossible to deliver satisfactory project results to the stakeholders. Once the important stakeholders and their needs are fixed, then the next step is to start exploring what strategies are needed to ensure the stakeholder satisfaction. Many of the existing measurement frameworks and methodologies appear to stop at a certain point. Once the strategies have been identified and the right ''leading and lagging'' measures are established, it is assumed that everything will be fine thereon. But studies have shown that around 90% of managers fail to implement and deliver their organization's strategies. One of the main reasons for such strategic failure maybe the organization's processes are not aligned with its strategies. And even if its processes are aligned, perhaps the capabilities required to operate these processes may not be. Thus, strategy selection is an important step in the performance evaluation that needs to be carefully addressed and can be used as a method to monitor to what extent organizational objectives have been decided to improve organizational performance (Patria et al., 2018; Neely et al., 2005).

4.2.3 Processes (F_3)

This facet is all about deciding what processes should be adopted and improved to increase the effectiveness of the whole workflow. According to Neely et al., 2005, processes are the blueprints to know what works are done, where, when, and how it will be executed. While deciding these processes, the following aspects are normally considered: quality (consistency, reliability, conformance, durability, accuracy, and dependability), quantity (volume, throughput, and completeness), time (speed,

delivery, availability, promptness, timeliness, and schedule), ease of use (flexibility, convenience, accessibility, clarity, support) and money (cost, price, value).

In the sense of the common business processes, these include: developing new products and services, generating demand, fulfilling demand, planning and managing the enterprise and so on. Liu et al., 2014 explained the process facet in the construction industry with an instance; bidding is an important function of the procurement of any public construction project which includes activities such as pre-qualification, shortlisting, invitation of tenders and interaction with bidders, tender evaluation, and bidder selection. Thus, a transparent and competitive bidding process is critical to the successful delivery of these projects and therefore the transparency and competitiveness of the bidding procedure must be considered to be a process performance indicator for these construction projects. Like this, all the major processes in a project that helps to achieve the previously set strategies can be evaluated by considering them under the process facet.

4.2.4 Capabilities (F_4)

In order to successfully implement the business processes in organizations, they must be supported by certain skills, physical infrastructures, technologies and human resources which are normally referred to as organizational capabilities (Neely et al., 2002). These capabilities determine the fundamental ability of an organization to compete with its competitors. As soon as the capabilities needed for the project are identified, it would be possible to assess whether the organization has these required capabilities or is there a need to implement them. In order to make the capability facet clearer, Neely et al. (2001) explained it with a process starting from ordering a product to its cash fulfilment. This process requires at least six different capabilities to successfully complete it, which are: Customer order handling capability, planning and scheduling capability, procurement capability, manufacturing capability, distribution capability and credit management capability. For EPC projects, these capabilities vary from one project to another depending upon the changing complexity of the project and the phase based nature of these projects.

4.2.5 Stakeholder Contribution (F_5)

This facet addresses the question of what all contributions does the company need and want from its stakeholders to develop their identified capabilities. For every stakeholder there is a question: what the organization wants and needs from them as well as what the stakeholder wants and needs from the organization in return. Customers want great products and services at a reasonable cost which brings them greater satisfaction. The organizations in return want their customers to be loyal towards their organization and profitable. Similarly, in the case of employees, organizations want loyal employees and they want their workforce to do their jobs with high productivity levels. In return, they grade or reward their employees based on their contribution. This symbiotic relationship between the organization and the stakeholder exists for all types of stakeholders whether we are talking about suppliers, customers, employees, investors, or the local community (Neely et al., 2001; Neely et al., 2005).

4.3 CLASSIFICATION OF PERFORMANCE INDICATORS

Performance Prism framework is all about the evaluation of a project from its stakeholders' perception. Therefore, in this study, five important stakeholder categories involved in EPC projects were chosen who were clients (public party), EPC contractors (private party), employees of the organization, material and equipment suppliers and the end-users of the projects. All the 45 project performance indicators were classified into five different facets ($F_1 – F_5$) of the Performance Prism framework as seen in Table 3.1. After that, the performance indicators are distributed into the five chosen stakeholder categories and are shown in Table 4.1.

Table 4.1: Classification of 45 indicators into various stakeholder categories

Sl. No.	Performance Indicators	Stakeholder
F_1 1	Client's satisfaction for time, cost & quality	Client
F_1 2	Contractor's satisfaction for time, cost & quality	Contractor
F_1 3	Employee's satisfaction for time, cost & quality	Employee
F_1 4	Supplier's satisfaction for time, cost & quality	Supplier
F_1 5	User's satisfaction for time, cost & quality	End-user
F_1 6	Profitability of the project	Client, Contractor, Employee

Sl. No.	Performance Indicators	Stakeholder
F_1 7	Appropriateness of the project size & location	Client, Contractor, Employee, Supplier
F_2 8	Performance level of the service provided	Client, Contractor, End-user
F_2 9	Value for money for the project	Client, Contractor, Employee, Supplier, End-user
F_2 10	Health, safety & environmental impact of the project	Client, Contractor
F_2 11	Technology diffusion in engineering, procurement & construction stages	Employee, End-user
F_2 12	Technology diffusion in material supply & management	Supplier
F_3 13	Competitiveness & transparency in the procurement process	Client
F_3 14	Effectiveness in communication and coordination between the stakeholders	Client, Contractor, Employee, Supplier, End-user
F_3 15	Appropriateness of the contract criteria for the project	Client, Contractor
F_3 16	Provision of payments on time for completed work by the client	Client
F_3 17	Effectiveness of facility maintenance and management	End-user
F_3 18	Efficiency of risk management (identification, analysis & allocation)	Contractor
F_3 19	Appropriateness in the budget and schedule estimates	Contractor, Employee
F_3 20	Degree of site management and supervision	Employee
F_3 21	Claim and dispute management	Employee
F_3 22	Degree of project team work and partnerships	Employee
F_3 23	Transportation of materials and equipments on time	Supplier
F_3 24	Appropriateness of supply contract criteria	Supplier
F_4 25	Efficient TCQ & material management system	Employee, Supplier

Sl. No.	Performance Indicators	Stakeholder
F_4 26	Favourability and efficiency of the legal framework	Client, Contractor, Supplier, End-user
F_4 27	Financial stability of the client	Client
F_4 28	Prior experience of client & EPC contractor	Client, Contractor
F_4 29	Reputable developer / strong and good private consortium	Contractor
F_4 30	Presence of skilled working personnel (employees)	Employee
F_4 31	Use of advanced planning and scheduling techniques	Employee
F_4 32	Financial stability of the EPC contractor	Contractor
F_4 33	Capability for right selection of project teams	Employee
F_4 34	Sufficient availability of good quality construction materials, equipments and skilled labour for the project	Employee, Supplier
F_4 35	Knowledge about the project for the users	End-user
F_5 36	Client's willingness to active participation	Client
F_5 37	Client's contribution to contractor selection	Client
F_5 38	Contractor's willingness to active participation	Contractor
F_5 39	Contractor's overall performance	Contractor
F_5 40	Employee's willingness to active participation	Employee
F_5 41	Employee's overall performance	Employee
F_5 42	Supplier's willingness to active participation	Supplier
F_5 43	Supplier's overall performance	Supplier
F_5 44	User's willingness to the infrastructure use	End-user
F_5 45	Presence of supporting & understanding community	End-user

Figure 4.2 shows the graphical representation of the developed performance evaluation model using the Performance Prism framework. Each stakeholder has various activities in a construction project and this classification is based on those activities. The indicator of stakeholder's satisfaction directly comes under the satisfaction facet of all stakeholders. Higher chances of obtaining profit from the project and the right degree of project complexity due to its size and location also affect their satisfaction aspect.

Good performance level of the constructed facility can act as a strategy to provide, for the client and contractor whereas it becomes a satisfaction aspect for its users. Similarly, obtaining the right value for money of the project, minimizing health, safety and environmental impacts caused due to it and including technology in all stages of the project are also some of the strategies of all stakeholders, since these are expected from each construction project for the mutual benefit of the users and the builders.

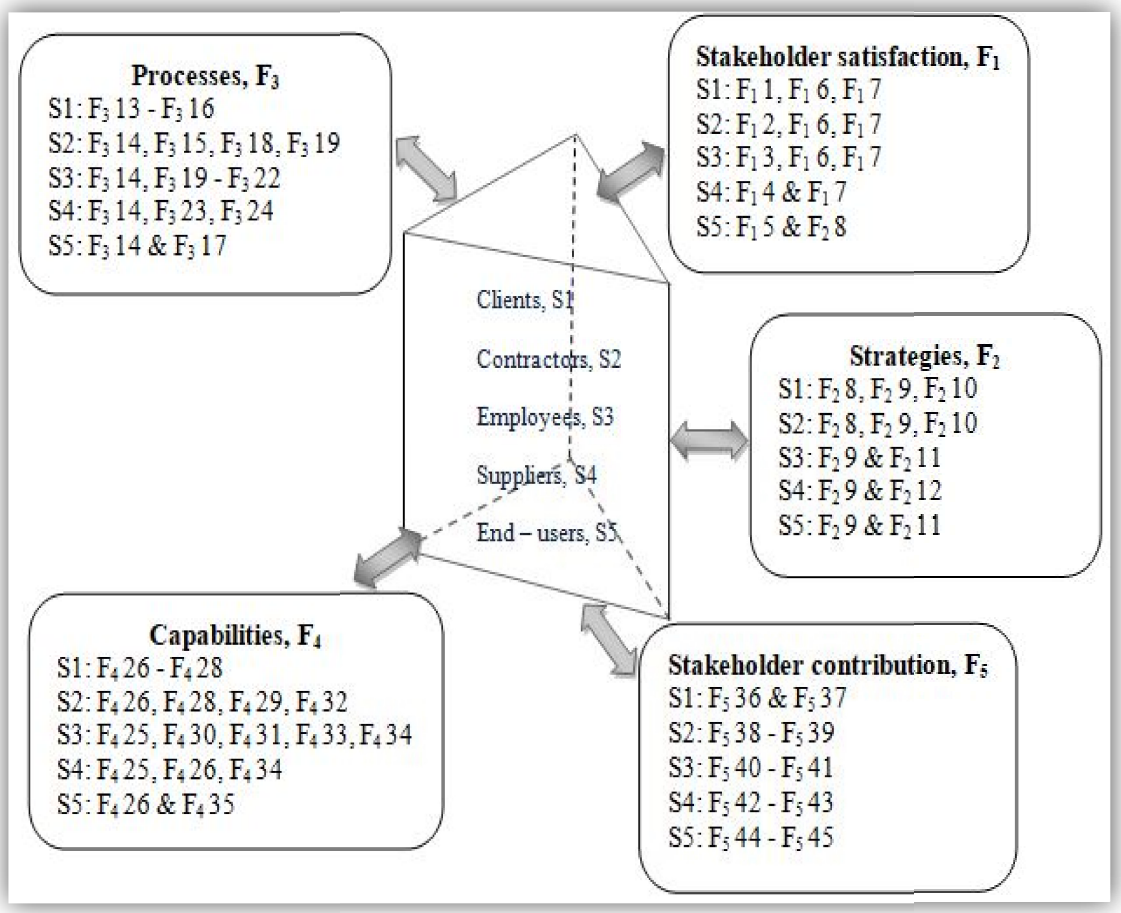

Figure 4.2: Schematic diagram of the formulated Performance Prism Model

The process facet of the model includes most of the important processes that have a chance for deviating from its pre-defined way thereby making an impact on the project performance. Tendering and contract management, communication and coordination between the stakeholders, payment mechanism, risk allocation, facility maintenance, estimation of budget and schedule of the project and so on are divided into different small processes for respective stakeholder categories under this facet.

In a similar manner, various capabilities that the stakeholders should possess like basic knowledge about the project for the users, financial stability of client and contractor, prior experience, reputation, advanced technologies, sufficient materials and its proper management are included in the capability facet. Presence or absence of these capabilities can definitely affect the project performance directly or indirectly.

The willingness and interest of each stakeholder can reflect in the final result of a project. Therefore, the fifth facet of the developed model (contribution facet) takes into consideration the overall contributions made by the stakeholders and their willingness to participate in the project. As the end-users are concerned, their willingness to use the constructed facility and their supportive nature during construction can act as their contribution.

4.4 SUMMARY

The whole idea behind the Performance Prism framework and each of its facets were explained in this section. Using this framework, different aspects of the project would be evaluated that corresponds to different stakeholders involved in the project, thereby giving a chance to measure the performance and competency of each stakeholder along with that of the project. In this study, five stakeholder categories of EPC projects were selected who were: clients, EPC contractors, employees, suppliers and end-users. An evaluation model has then been developed using the 45 performance indicators on the basis of the Performance Prism framework. The detailed classification of the indicators into the five facets of the framework for each of the stakeholder categories was also provided here.

CHAPTER 5

PRIORITIZATION OF INDICATORS USING ANALYTICAL HIERARCHY PROCESS (AHP)

5.1 GENERAL

After the classification of performance indicators in to different facets and stakeholder categories, the next step was to find out the priority weights of the indicators using Analytical Hierarchy Process (AHP)**.** AHP was developed by Prof. Thomas L. Saaty in 1971 as a multi criteria decision making mathematical tool which is used to get priority weights for different factors. The priority weights are calculated with some ratings obtained by conducting an AHP questionnaire survey. To make a decision in an organised way and to generate priority weights, following steps must be implemented (Saaty, 2008):

1) Define the problem for which decision is to be made.
2) Structure the decision hierarchy from the top to bottom as seen in figure 5.1, with the goal or objective of the decision, followed by criteria on which subsequent elements depend and finally to the lowest level which usually is a set of the alternatives for the problem.

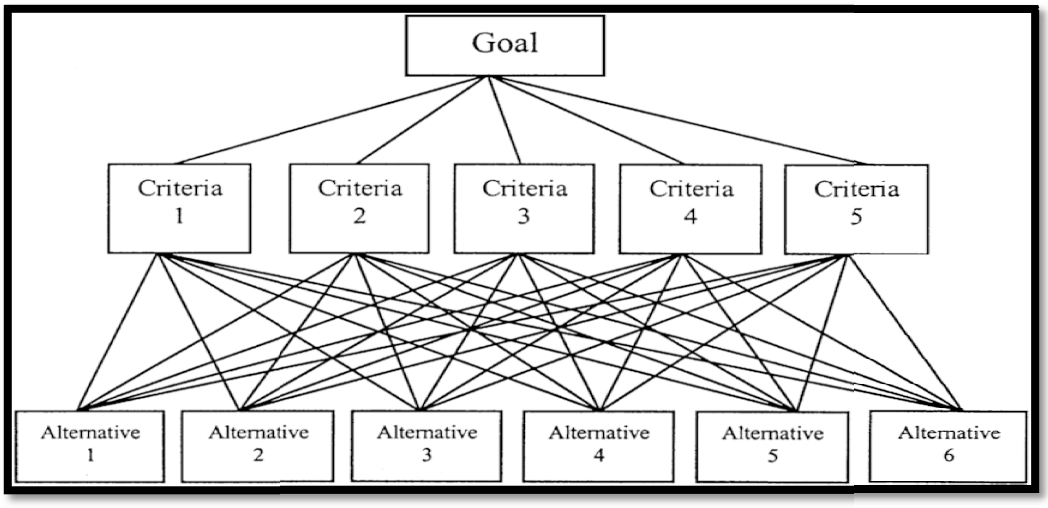

Figure 5.1: General structure of Analytical Hierarchy Process (Badri., 2001)

3) Construct a set of pair wise comparison matrices by comparing each element in an upper level with the elements in the level immediately below with respect to it.

4) Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Repeat this for every element.

To make these comparisons, a scale of numbers is needed, that indicates how many times more important or dominant one element is over another element with respect to the criterion with which they are compared. The scale developed by Saaty is shown in the below table 5.1.

Table 5.1: Saaty's AHP scale (Saaty., 2008)

Degree of Importance	Scale	Definition
1	Equal importance	Two activities contribute equally to the goal
3	Moderate importance	Experience and judgement slightly favour one activity over the other
5	Strong importance	Experience and judgement strongly favour one activity over the other
7	Very strong importance	One activity is strongly favoured over the other; element is very dominant as seen in practice
9	Extreme importance	The evidence is favour of one activity over the other to the greatest extent possible
2,4,6,8	Intermediate values between two judgements	They are used to express preferences that are between the values of above scale
Reciprocal values	If activity i has one of the above numbers, by comparing i to j, the inverse of i with respect to j is obtained	

5.2 PRIORITIZATION OF PERFORMANCE INDICATORS

In this study, in order to conduct AHP analysis, different AHP questionnaires (given in Appendix B) were prepared and distributed to construction professionals from all the five stakeholder categories including clients, contractors, employees, material and equipment suppliers who had experience in working in EPC projects in

Kerala and finally the end-users, who are the users of these projects. The designations of the respondents of AHP survey from client, contractor, employee and supplier categories are shown in the figures 5.2 – 5.5. Similarly, the experience, in years, of the respondents of AHP survey in working in EPC projects is shown in figures 5.6 – 5.9.

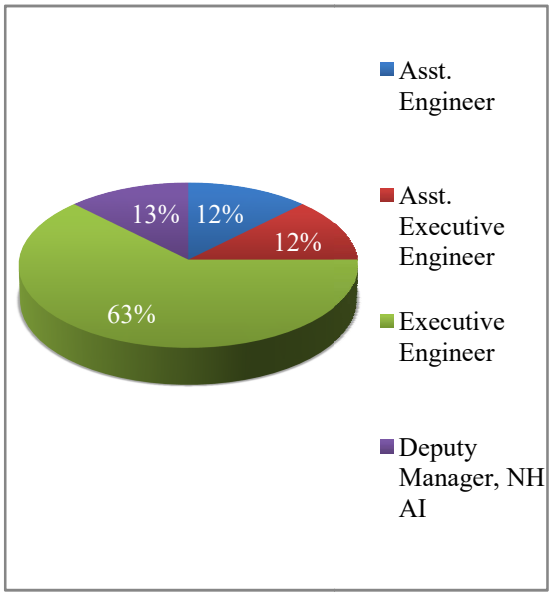

Figure 5.2: Designations of client respondents for AHP survey

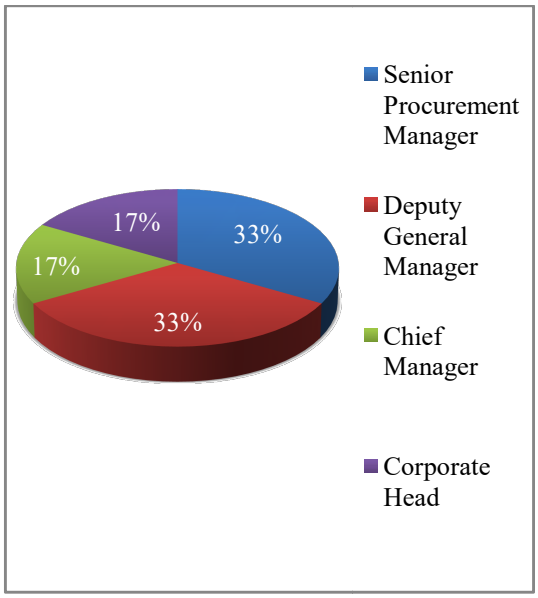

Figure 5.3: Designations of EPC contractor respondents for AHP

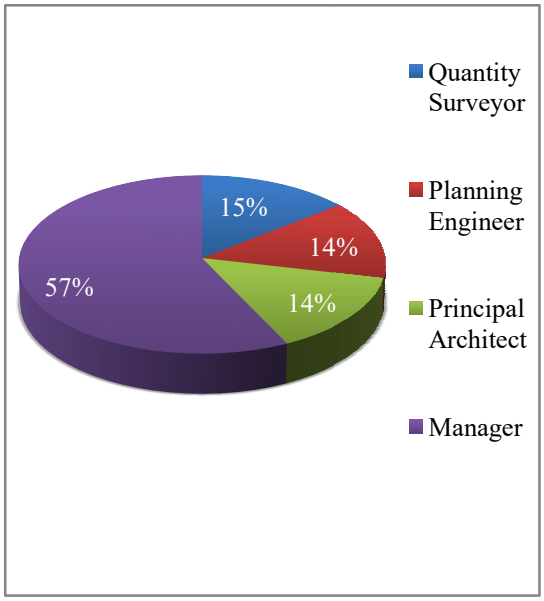

Figure 5.4: Designations of employee respondents for AHP survey

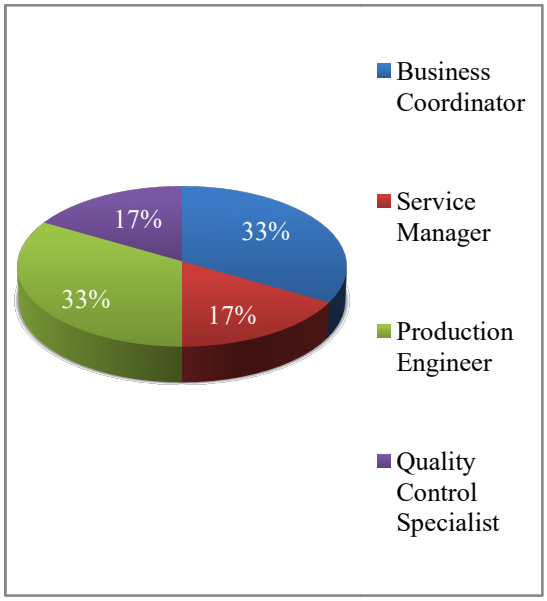

Figure 5.5: Designations of supplier respondents for AHP survey

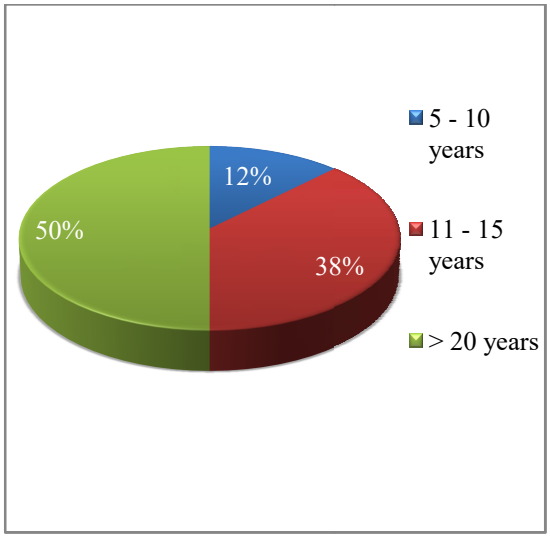

Figure 5.6: Experience of client respondents for AHP survey

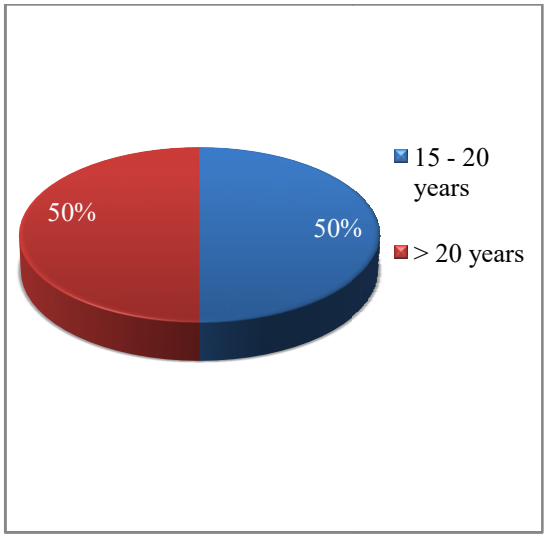

Figure 5.7: Experience of EPC contractor respondents for AHP survey

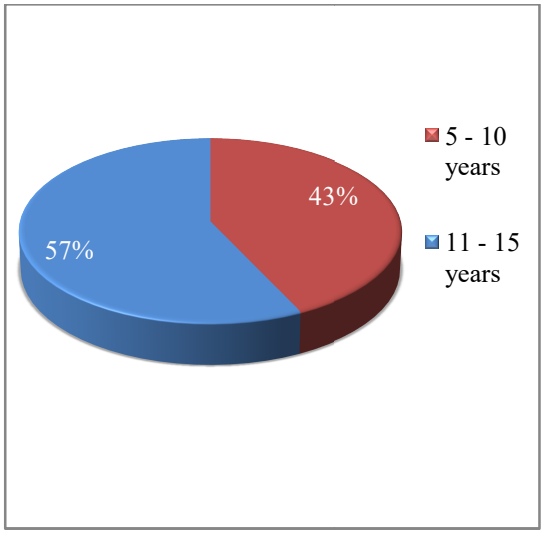

Figure 5.8: Experience of employee respondents for AHP survey

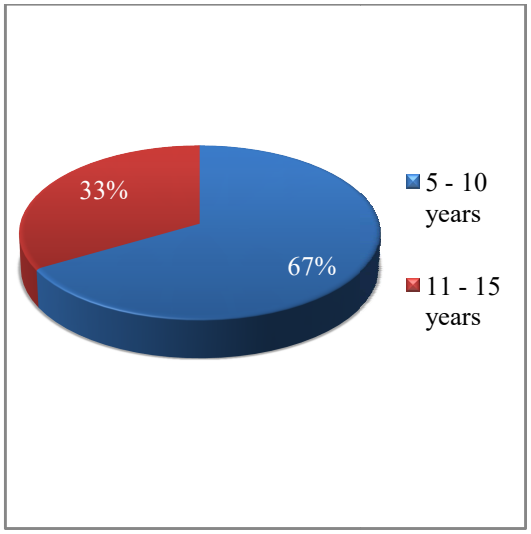

Figure 5.9: Experience of supplier respondents for AHP survey

The developed 3 level hierarchy model for AHP survey is shown in figure 5.10. Performance evaluation of EPC projects using Performance Prism framework is the ultimate goal of this study. For that, the selected five stakeholder categories (first level) and five facets of the evaluation framework (second level) act as the criteria and sub criteria. The 45 performance indicators classified under these criteria and sub - criteria act as the alternatives (third level).

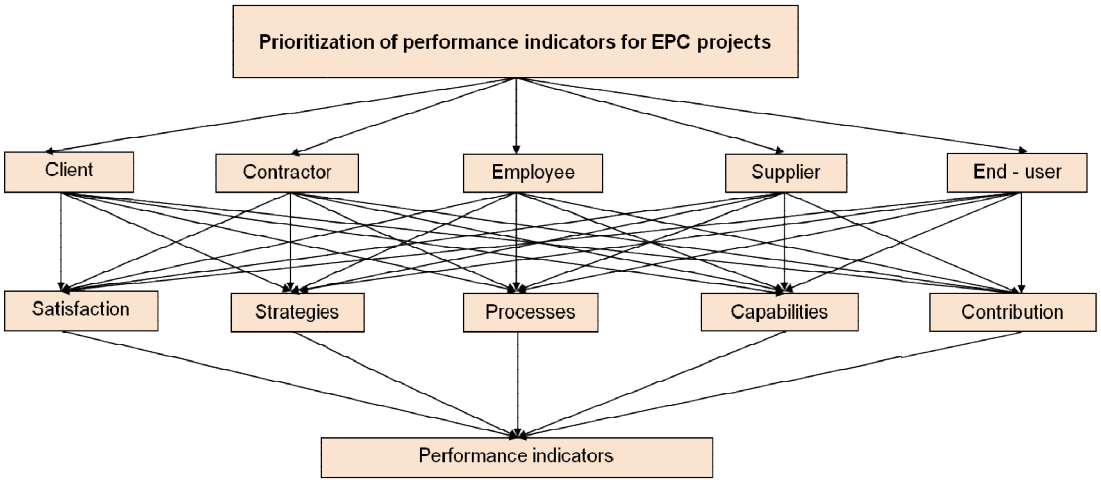

Figure 5.10: Structure of AHP hierarchy model

An important step in the AHP analysis is to check the consistency of the judgements made. The consistency values for all the judgements in an AHP analysis must be within the limit of 0.1 in order for the collected data to be consistent. If not, the survey must be conducted again to get consistent results. Here, the consistency values of all the samples were below 0.1 and hence were in the acceptable range.

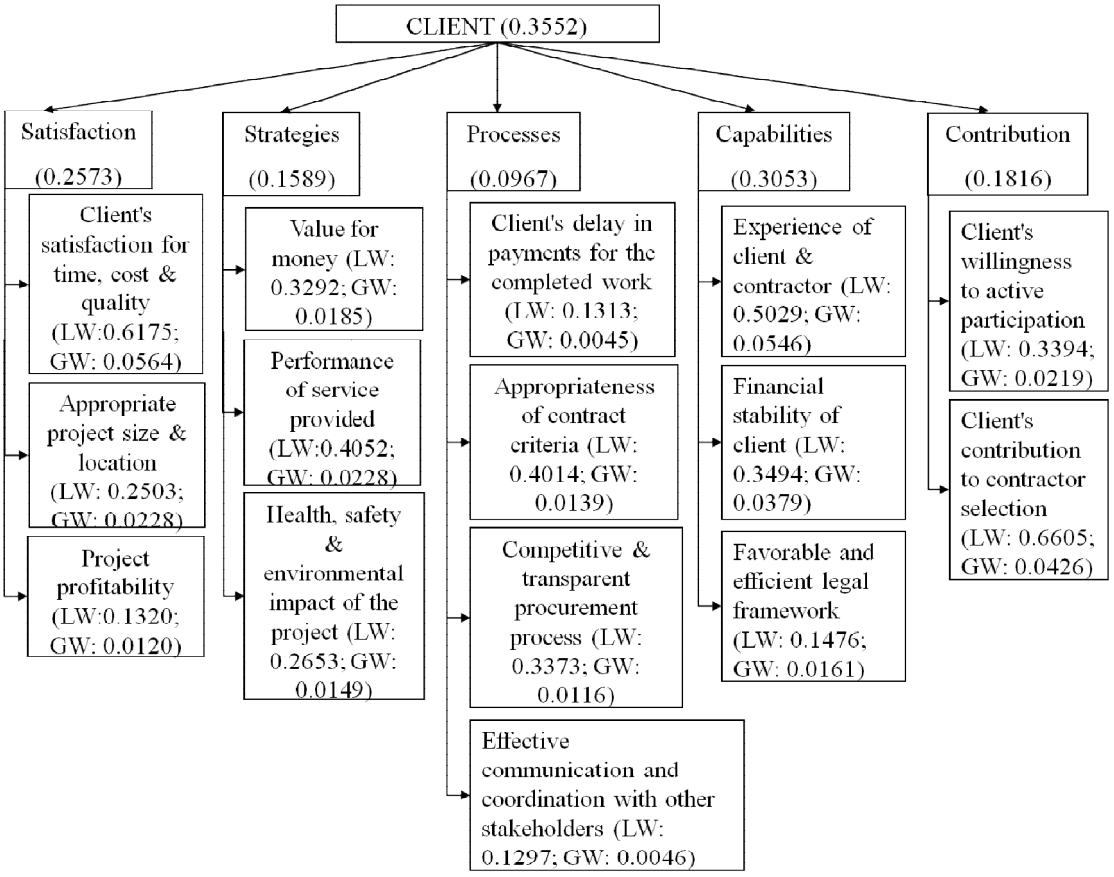

Figure 5.11: Structure of AHP hierarchy model for client along with AHP priority weights

The results of AHP analysis for the five stakeholder categories are shown in figures 5.11 – 5.15 which were obtained with the help of AHP (Analytic Hierarchy Process) Calculation software by CGI. The priority weights for all the three levels are shown in the figures. The local weights (LW) of the indicators represent their individual AHP weights whereas their global weights (GW) represent their overall priority weights which give the product of priority weights of all the three levels.

From figure 5.11, in the client category, 'Client's satisfaction for time, cost and quality' and 'Experience of client and contractor' were the indicators having highest priority weights of 0.0564 and 0.0546 respectively.

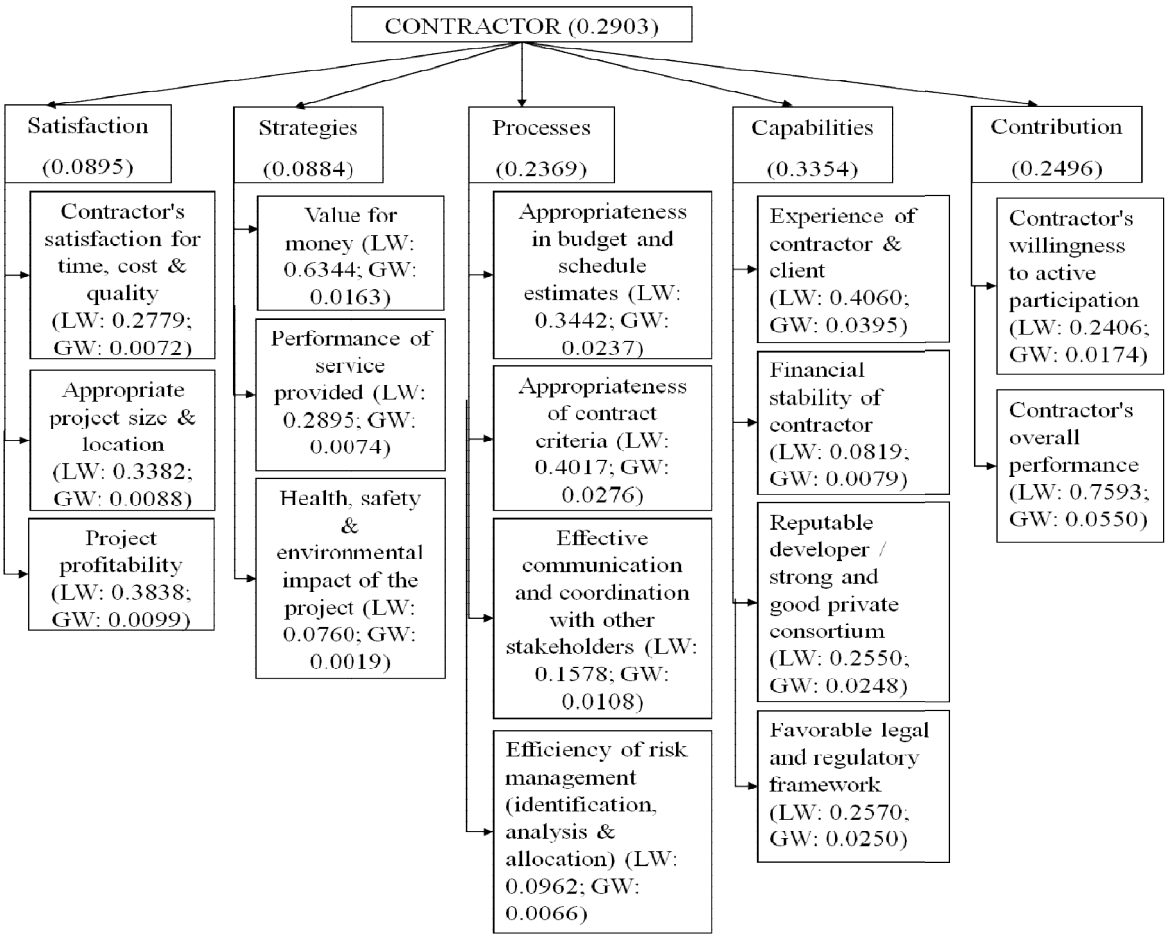

Figure 5.12: Structure of AHP hierarchy model for EPC contractor along with AHP priority weights

As seen in figure 5.12, in the contractor category, 'Contractor's overall performance' and 'Experience of contractor and client' were the indicators having highest priority weights of 0.0550 and 0.0395 respectively. According to Nassar and AbouRizk, 2014, a contracting company should always maintain good relationship with its clients as it is the only way to ensure its continued business growth.

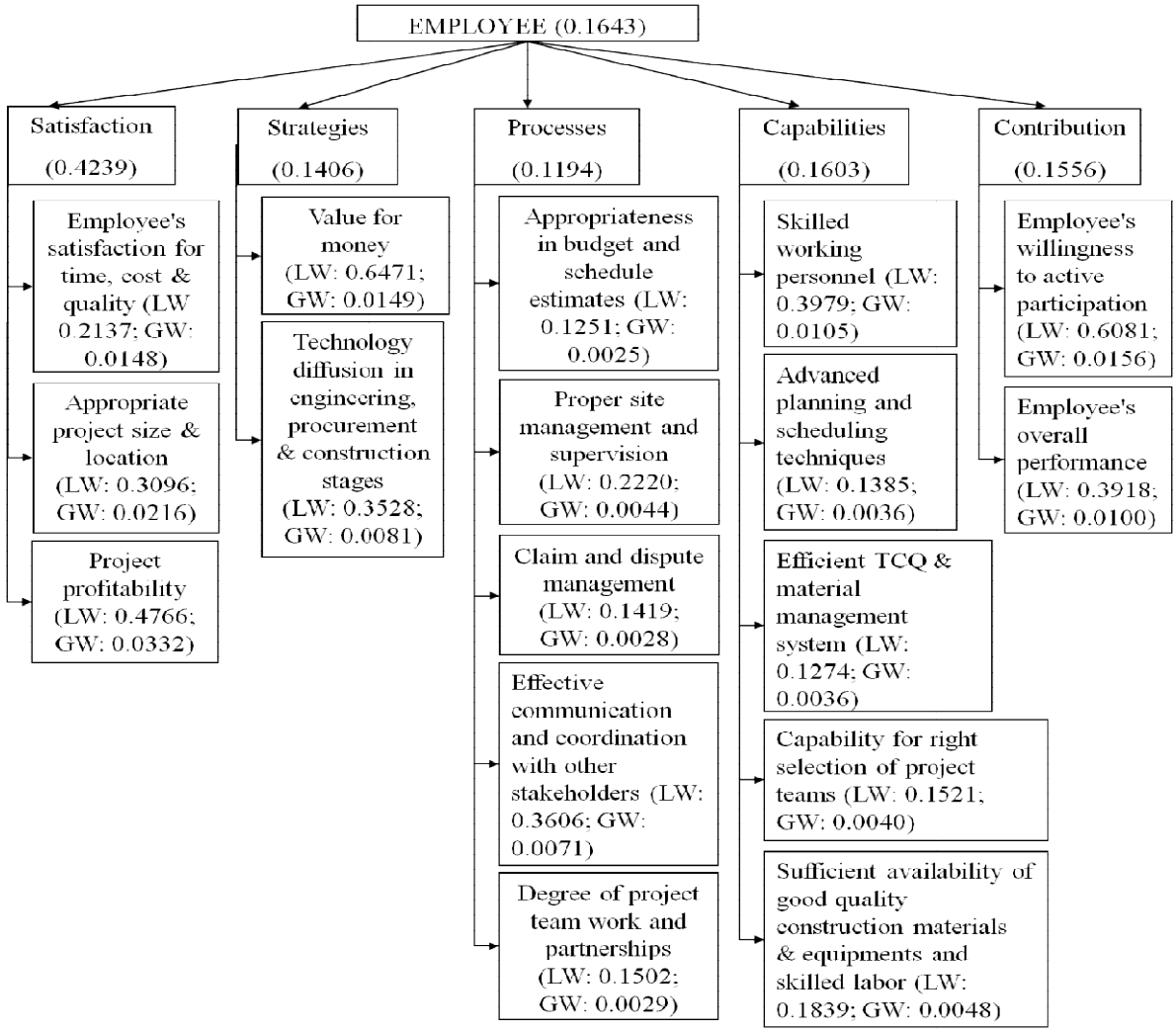

Figure 5.13: Structure of AHP hierarchy model for employees along with AHP priority weights

Similarly from figure 5.13, in the employee category, 'Project profitability' and 'Appropriateness of the project size and location' were seen having highest priority weights of 0.0332 and 0.0216 respectively. Profitability of a project is the revenue earned from the project and a higher profitability is always desired by all the parties involved. The size and location of the project also affects the project performance because, as the location becomes tough and size becomes large, it makes the project

complexity higher and thus risks and procedures involved would be higher. In the supplier category, from figure 5.14, it was seen that 'Value for money' and 'Supplier's overall performance' were having highest priority weights of 0.0548 and 0.0238 respectively. Value for money can be defined as the optimum combination of the life-cycle cost, service quality of the asset, and the end - user's satisfaction. This is one of the main strategies of all the stakeholders involved. According to Noorizadeh et al., 2019, suppliers have a huge contribution in project cost, quality and time. Involving high performance suppliers in the project can make the contractor move towards high performance construction which makes a supplier's overall performance important for a project.

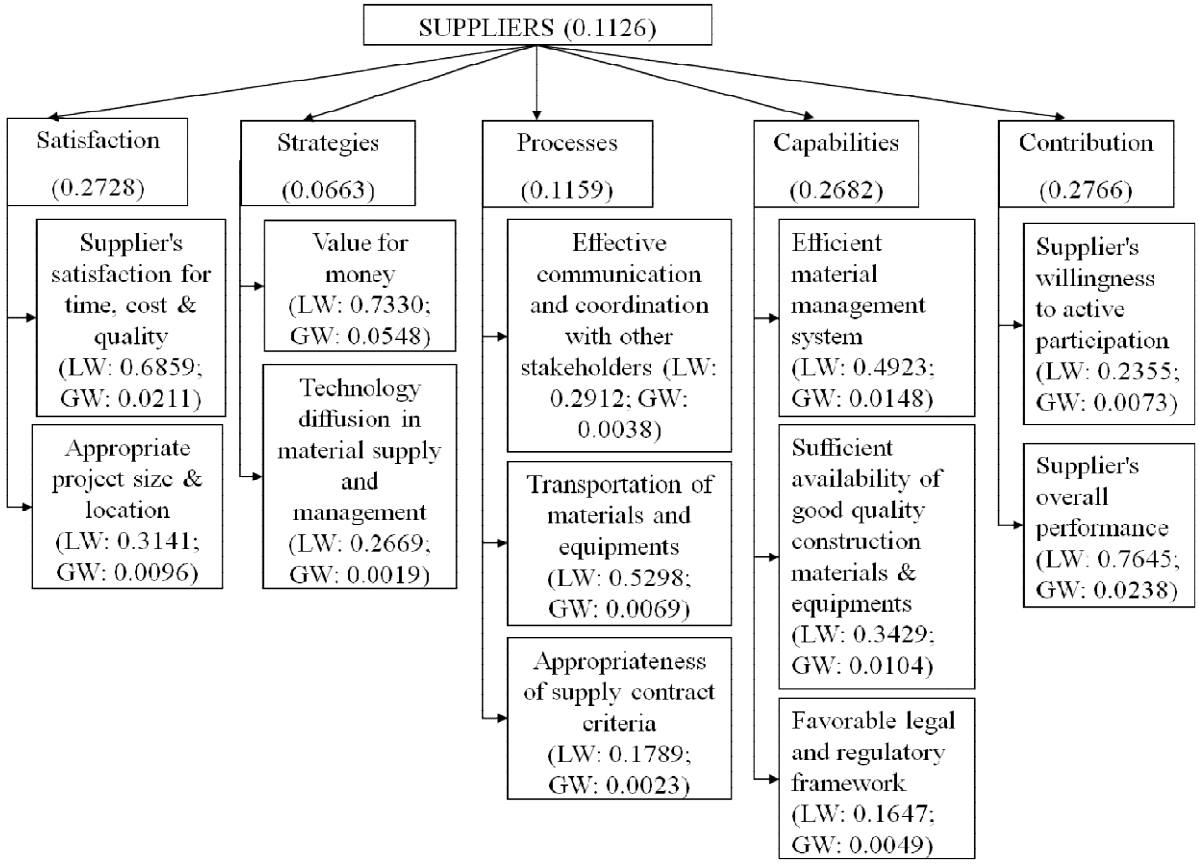

Figure 5.14: Structure of AHP hierarchy model for suppliers along with AHP priority weights

Client sector constructs the infrastructural facilities ultimately for the end – users to have better facilities and standard of living. Therefore, their satisfaction and the performance of the infrastructure are very important. This is proven in figure 5.15 which showed that in the end-user category, 'User's satisfaction for time, cost and

quality' and 'Performance of the service provided' were the ones having highest priority weights of 0.0218 and 0.0184 respectively.

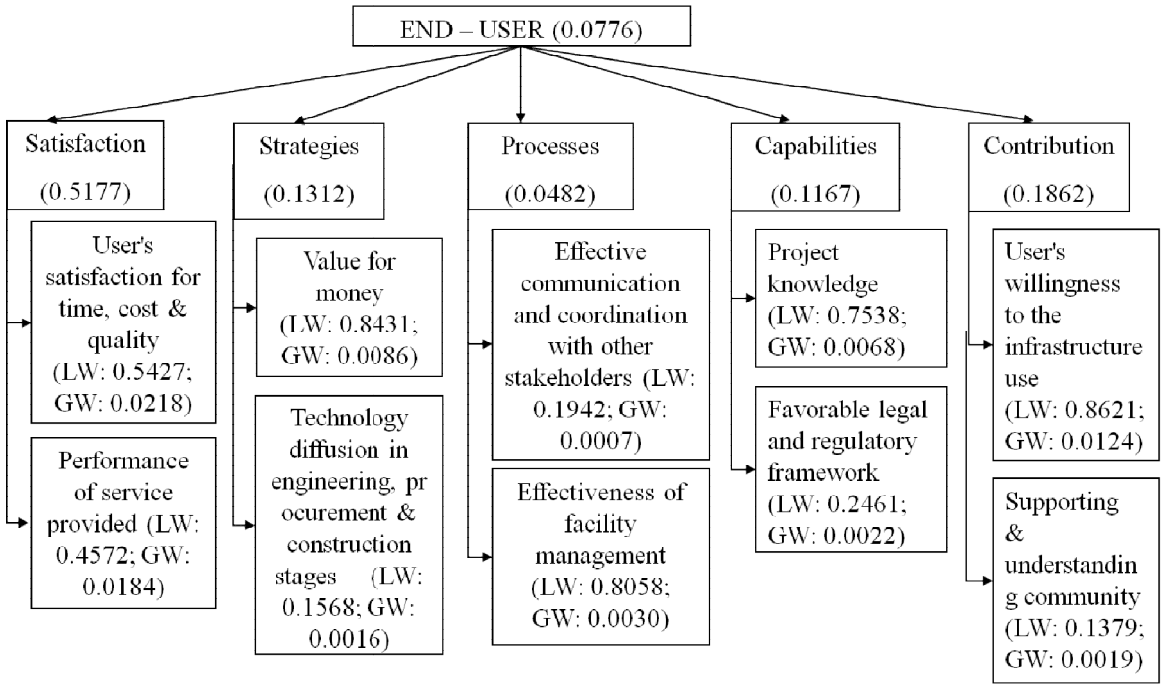

Figure 5.15: Structure of AHP hierarchy model for end-users along with AHP priority weights

5.3 SUMMARY

This section deals with the analysis using AHP tool. The mathematical tool developed by Prof. Thomas L. Saaty was used in this study for ranking of performance indicators by determining their priority weights. AHP questionnaire survey was conducted with five stakeholder categories of EPC project in Kerala and the priority weights of the indicators for each of the stakeholder categories were determined. Client's satisfaction, contractor's and supplier's overall performance, experience of the client and contractor, user's satisfaction, performance of the infrastructure, value for money, project profitability and appropriateness of the project size and location were the top ranked performance indicators.

CHAPTER 6

PERFORMANCE EVALUATION OF KOLLAM BYPASS PROJECT

6.1 GENERAL

Kollam bypass project comes under the Cherthala-Thiruvananthapuram section of NH 66 (NH 47) under National Highway Development Project (NHDP) phase III in the State of Kerala. The project measures 13.141 km in length and starts from Kavanad in the north to Mevaram in the south. This bypass touches three major National Highways which: NH 66 (Panvel to Kanyakumari), NH 183 (Kollam to Dindigul) and NH 744 (Kollam to Madurai). It was constructed as a joint venture project between the central and state government through Engineering, Procurement and Construction (EPC) mode. The stretch of 3 km in length from Mevaram to Ayathil was completed in the year 1993 and 1.5 km Ayathil-Kallumthazham stretch was completed in 1999. The remaining Kallumthazham-Kavanad stretch was then completed in 2019 and was inaugurated on 15th January in the same year (Kurian and Surendran, 2017).

6.2 PROCEDURE FOR PERFORMANCE EVALUATION

The step by step procedure followed to implement the performance evaluation of Kollam bypass project is given below. The performance evaluation model formulated using the Performance Prism framework in section 4.3 is used for this purpose.

- Initially five stakeholder categories were selected for developing performance evaluation model using Performance prism framework (client, contractor, employee, supplier and end-user). Experienced people from those five stakeholder categories in the Kollam bypass project were identified.
- Different questionnaires were prepared and distributed to each of the stakeholders to mark the prevalence rating and importance rating of the project performance indicators on a scale of 1 to 5 in which 1 represented lowest score and 5 represented highest score. The questionnaires are attached as Appendix C.

- The collected ratings of the indicators were then used to find out its Relative Importance Index (RII). It is one of the most widely used methods to find out the relative importance of different factors. Here, RII under both ratings were determined separately (Kassem, 2020).

Relative Importance Index, RII is given by Eq. 6.1:

$$\text{RII} = \frac{\sum W}{A*N} \tag{6.1}$$

Where, W – the rating given to each indicators by a respondent; A – highest rating in the rating scale (here, A = 5) and N – total number of respondents

- Performance index of each indicator is then determined by using Eq. 6.2:

Performance index (PI) of each indicator = RII under prevalence rating (PR) * RII under importance rating (IR) (6.2)

- The average of the PI values of the indicators under each facet for each stakeholder was then calculated to obtain the PI of that facet (Gunduz et al., 2013). Performance of each facet in percentage was then obtained by normalizing the PI values. To get the normalized percentage values, the PI of each facet was divided by the total PI of that stakeholder category and multiplied it by 100.
- The PI value of each stakeholder was then obtained by taking the sum of PI values of all the five facets under that category. By normalizing these values, percentage of performance of each stakeholder was also determined. To get the normalized percentage values, the total PI of each stakeholder was divided by the total PI of the project and multiplied it by 100.
- The sum of the PI values of all the five stakeholders was taken to get the overall PI of the Kollam bypass project. By normalizing this value, percentage of performance of the project was determined. To get the normalized percentage value, the total PI of the project was divided by the total maximum possible PI of the project, which is 25 in this study and multiplied it by 100. (The maximum possible PI value for each stakeholder is 5 since the maximum value of RII is 1 and there are only five facets in each

category. Hence, for five stakeholder categories, the total maximum possible PI value will be 25).

6.3 DEMOGRAPHICS OF THE RESPONDENTS

The Figures 6.1 – 6.4 given below shows the demographics of the respondents of the survey conducted for performance evaluation of Kollam Bypass project. Experienced people from all the five stakeholder categories who were part of the project were contacted and the responses were collected via email. The responses from end-user category were collected from people working in different sectors having minimum education to in order to understand the questionnaire and purpose of the project.

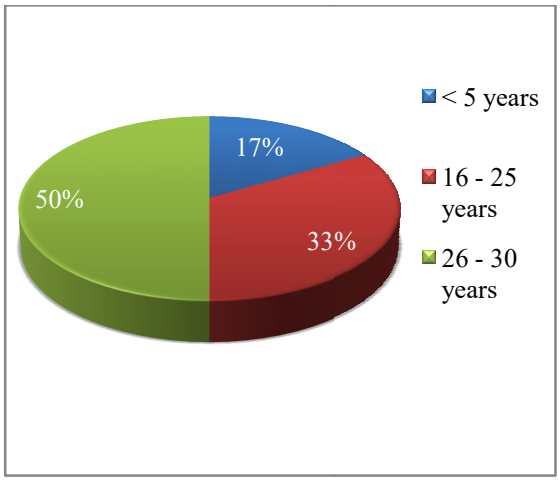

Figure 6.1: Experience of client respondents

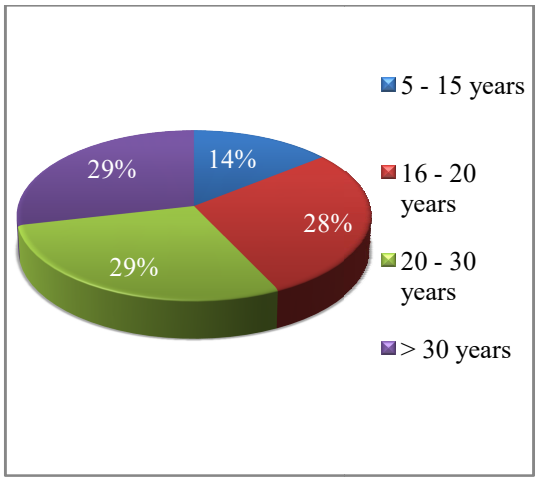

Figure 6.2: Experience of contractor respondents

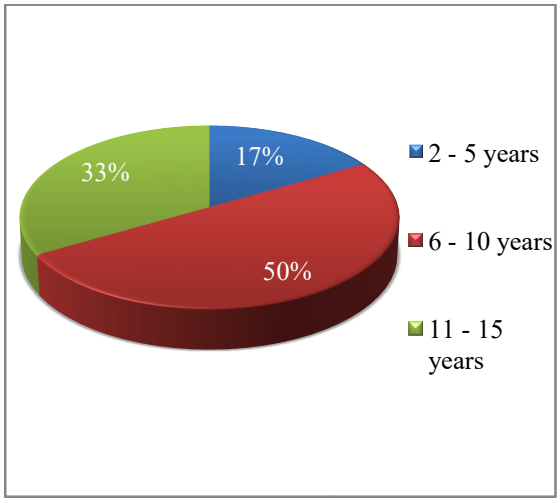

Figure 6.3: Experience of employee respondents

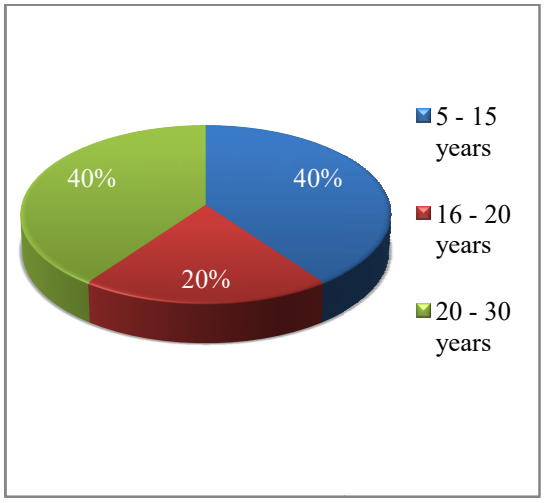

Figure 6.4: Experience of supplier respondents

6.4 COMPARISON BETWEEN RII AND AHP RANKINGS

Tables 6.1 – 6.5 shows the obtained relative importance indices of the project performance indicators for the five stakeholder categories in the Kollam Bypass project along with the AHP priority weights of the indicators. Since both AHP and RII analyses were conducted on the same project evaluation model using the same performance indicators, the results from these two analyses gives the ranking of the same parameters. Therefore, the ranks of the performance indicators for project performance evaluation of EPC projects in Kerala can be plotted in the same graph for each stakeholder category, to show the similarities and variations in it as shown in figures 6.5 – 6.9.

Table 6.1: RII and AHP values of indicators for client category

Performance Indicators	RII value	AHP Rating
Client's satisfaction for time, cost & quality	0.83	0.0564
Profitability of the project	0.97	0.012
Appropriateness of the project size & location	0.9	0.0228
Performance level of the service provided	0.83	0.0228
Value for money of the project	0.9	0.0185
Health, safety & environmental impact of the project	0.73	0.0149
Competitiveness & transparency in the procurement process	0.9	0.0116
Effectiveness in communication and coordination between the stakeholders	0.87	0.0046
Appropriateness of the contract criteria for the project	0.97	0.0139
Provision of payments on time for completed work by the client	0.9	0.0045
Favorability and efficiency of the legal framework	0.73	0.0161
Financial stability of the client	0.8	0.0379
Prior experience of client & EPC contractor	0.97	0.0546
Client's willingness to active participation in the project	0.83	0.0219
Client's contribution to contractor selection	0.6	0.0426

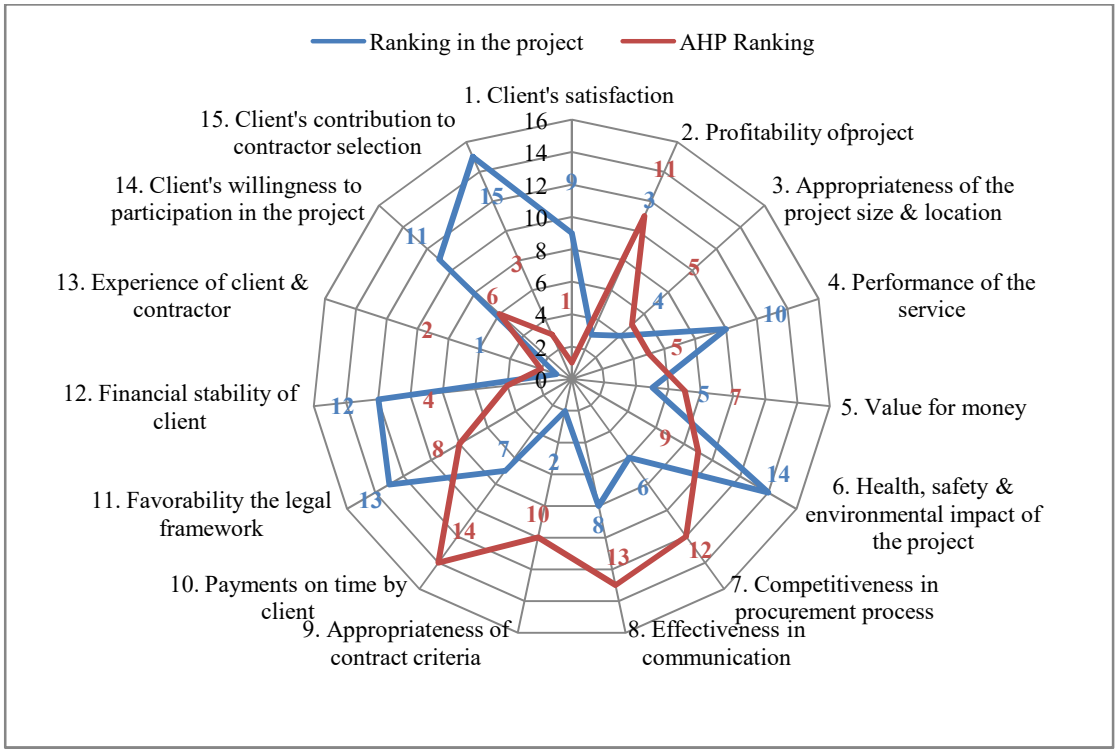

Figure 6.5: Comparison of AHP and RII rankings of indicators for client category

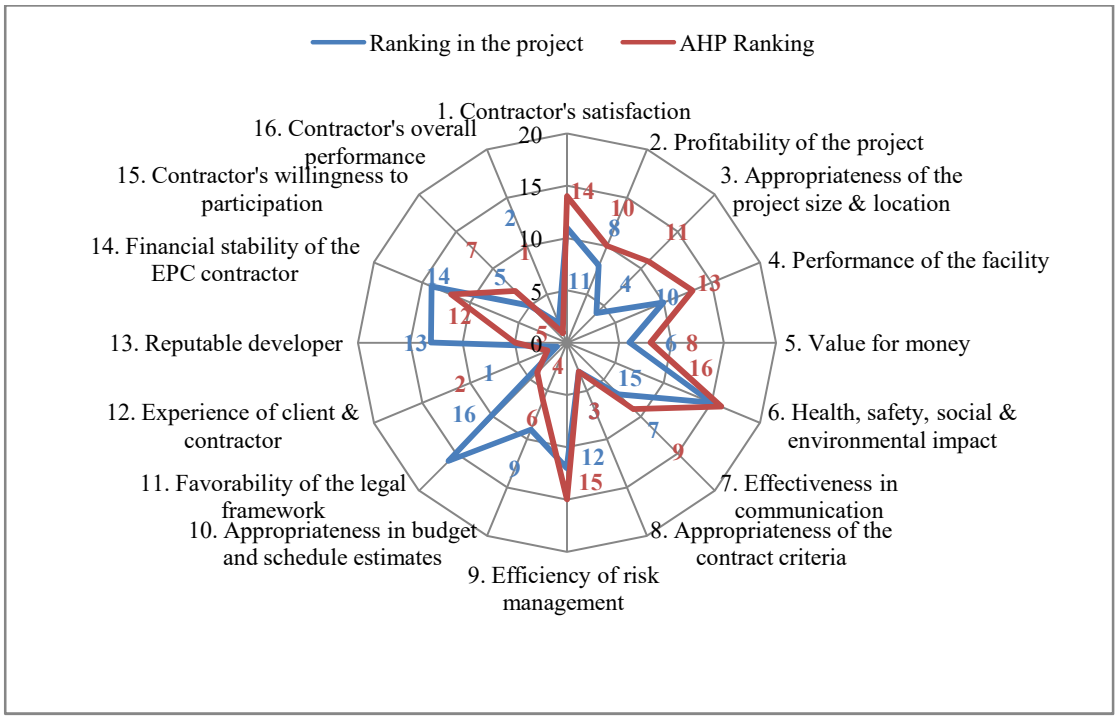

Figure 6.6: Comparison of AHP and RII rankings of indicators for contractor category

Table 6.2: RII and AHP values of indicators for contractor category

Performance Indicators	RII value	AHP Rating
Contractor's satisfaction for time, cost & quality	0.8	0.0072
Profitability of the project	0.83	0.0099
Appropriateness of the project size, design & location	0.94	0.0088
Performance level of service provided	0.8	0.0074
Value for money of the project	0.83	0.0163
Value for money of the project	0.69	0.0019
Health, safety, social & environmental impact of the project	0.83	0.0108
Effectiveness in communication and coordination between the stakeholders	0.94	0.0276
Appropriateness of the contract criteria for the project	0.8	0.0066
Efficiency of risk management (identification, analysis & allocation) in the project	0.8	0.0237
Appropriateness in the budget and schedule estimates of the project	0.63	0.0250
Favourability and efficiency of the legal framework	0.97	0.0395
Prior experience of client & EPC contractor	0.77	0.0248
Reputable developer / strong and good private consortium	0.71	0.0079
Contractor's willingness to active participation in the project	0.86	0.0174
Contractor's overall performance in the project	0.94	0.055

The comparison for the client category is shown in figure 6.5. Some of the ranks of the indicators in the client category were similar like experience of the client and contractor, value for money and appropriateness of the project size and location. In AHP analysis, ‘client’s satisfaction for time, cost and quality’ was having the highest rank whereas that place was given to ‘prior experience of client & contractor’ in the RII analysis.

In the contractor category as shown in figure 6.6, some of the performance indicators were showing same ranks or adjacent ranks like overall performance of the contractor, prior experience and appropriateness in the contract criteria. Some other lower ranked indicators were also showing almost similar results.

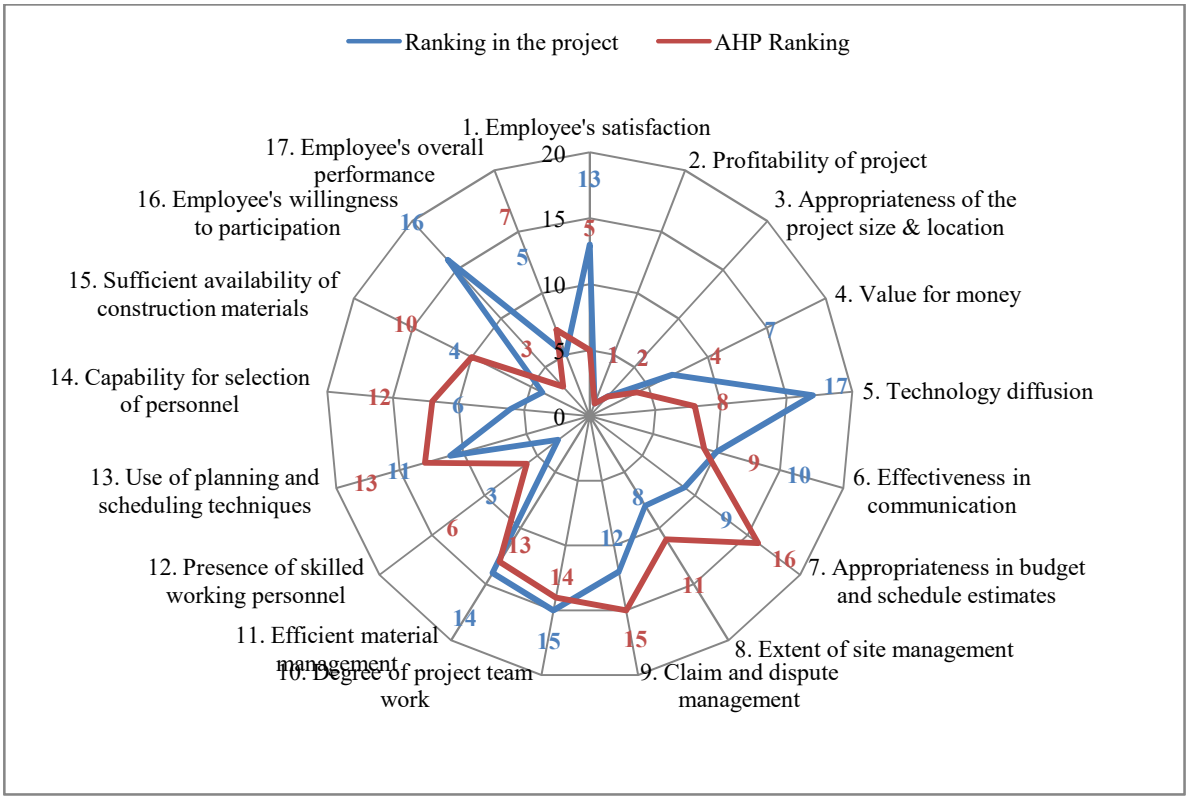

Figure 6.7: Comparison of AHP and RII rankings of indicators for employee category

Table 6.3: RII and AHP values of indicators for employee category

Performance Indicators	RII value	AHP Rating
Employee's satisfaction for time, cost & quality	0.73	0.0148
Profitability of the project	1	0.0332
Appropriateness of the project size, design & location	1	0.0216
Value for money of the project	0.83	0.0149
Technology diffusion in engineering, procurement & construction stages	0.67	0.0081
Effectiveness in communication and coordination between the stakeholders	0.8	0.0071
Appropriateness in the budget and schedule estimates of the project	0.83	0.0025
Extent of site management and supervision	0.83	0.0044
Claim and dispute management	0.8	0.0028
Degree of project team work and partnerships	0.73	0.0029
Efficient TCQ & material management	0.73	0.0036
Presence of skilled working personnel	0.97	0.0105
Use of advanced planning and scheduling techniques	0.8	0.0036

Performance Indicators	RII value	AHP Rating
Capability for right selection of personnel in the project	0.87	0.0040
Sufficient availability of good quality construction materials, equipment and skilled labour	0.97	0.0048
Employee's willingness to active participation in the project	0.67	0.0156
Employee's overall performance in the project	0.9	0.0100

From figure 6.7, it was observed that the employee category was also having similarities in the ranks of some of the indicators as seen in the client category. The highest ranked indicators in this category using both the analyses were the same which were 'project profitability' and 'appropriateness of the project size & location'.

The graph showing comparison of ranks of the performance indicators in the supplier category as shown in figure 6.8 was showing a trend almost like that of the contractor category. Some of the ranks were similar or nearly similar.

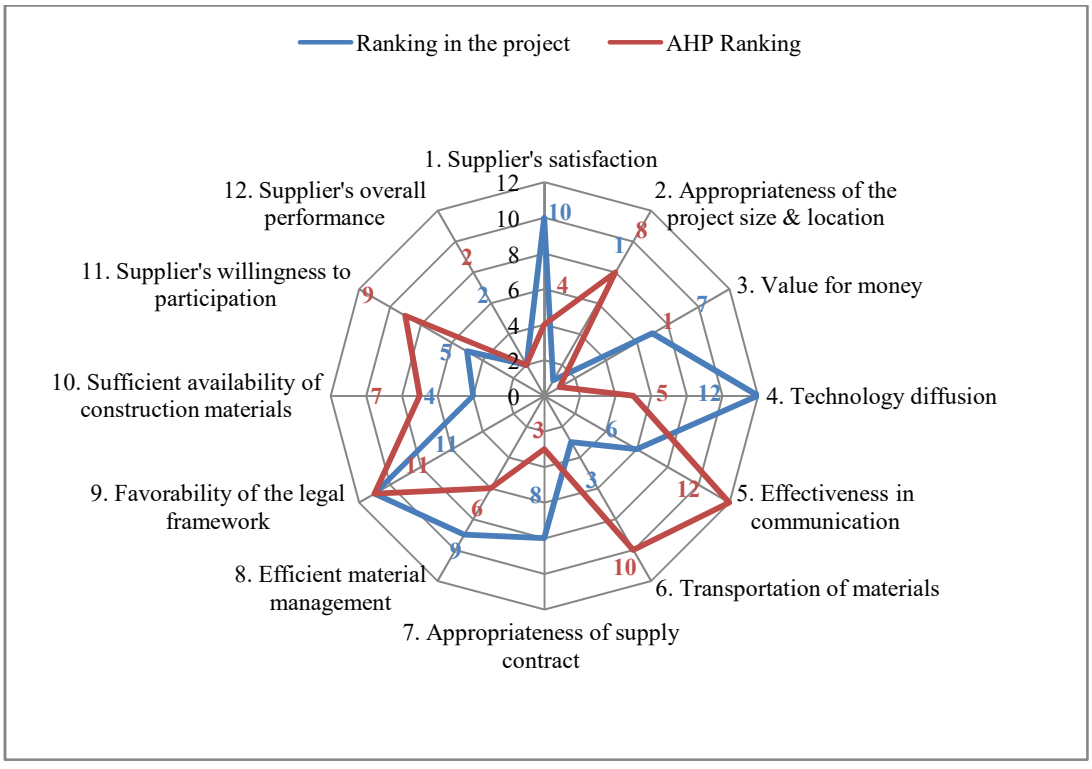

Figure 6.8: Comparison of AHP and RII rankings of indicators for supplier category

Table 6.4: RII and AHP values of indicators for supplier category

Performance Indicators	RII value	AHP Rating
Supplier's satisfaction for time, cost & quality	0.76	0.0211
Appropriateness of the project size & location	1	0.096
Value for money of the project	0.84	0.0548
Technology diffusion in material supply and management	0.64	0.0019
Effectiveness in communication and coordination between the stakeholders	0.88	0.0038
Transportation of materials and equipment on time	0.96	0.0069
Appropriateness of supply contract criteria	0.84	0.0023
Efficient TCQ & material management	0.8	0.0148
Favourability and efficiency of the legal framework	0.72	0.0049
Sufficient availability of good quality construction materials, equipment and skilled labour	0.88	0.0104
Supplier's willingness to active participation in the project	0.88	0.0073
Supplier's overall performance in the project	0.96	0.0238

Table 6.5: RII and AHP values of indicators for end-user category

Performance Indicators	RII value	AHP Rating
User's satisfaction for time, cost & quality	0.92	0.0218
Performance level of the service provided	0.88	0.0184
Value for money for the project	0.88	0.0086
Technology diffusion in engineering, procurement & construction stages	0.72	0.0016
Effectiveness in communication and coordination between the stakeholders	0.72	0.0007
Effectiveness of facility maintenance and management	0.8	0.0030
Favourability and efficiency of the legal framework	0.72	0.0022
Knowledge about the project for the users	0.72	0.0068
User's willingness to the infrastructure use	0.76	0.0124
Presence of supporting & understanding community	0.68	0.0019

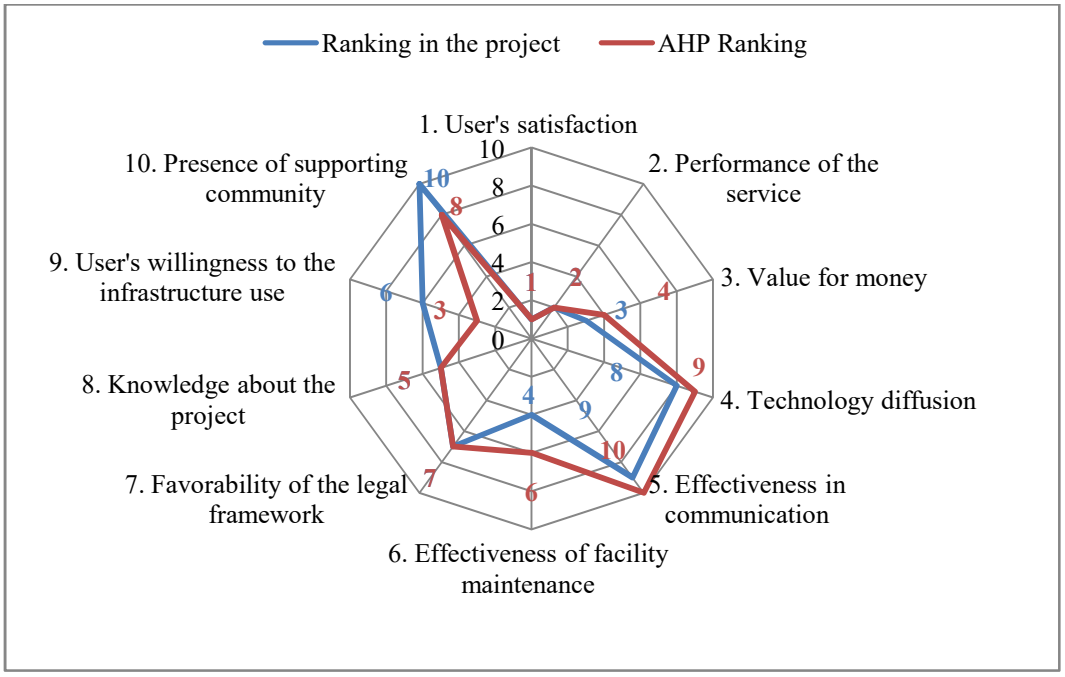

Figure 6.9: Comparison of AHP and RII rankings of indicators for end-user category

When the AHP and RII analysis results of the end–user category were compared, it was seen from figure 6.9 that, the rank of most of the indicators were the same or nearly same. In both analyses, the 'user's satisfaction for time, cost and quality' and 'performance of service provided' were the indicators with higher ranks.

The questionnaire survey for AHP and RII analyses was conducted from different personnel. The former responses were collected from professionals working in EPC projects in Kerala in general, whereas the latter responses were collected from the stakeholders of a specific EPC project (Kollam Bypass project). Since RII analysis was based on a specific EPC project, the responses would be based on the conditions existed in that project. But in AHP, the responses were from people working in different EPC projects which gave the ranking of the indicators on a general basis. This might have created a difference in the ranking of these indicators.

6.5 RESULTS OF PERFORMANCE EVALUATION

The performance indices for the indicators and the facets for the Kollam Bypass project determined using the RII values for the five stakeholder categories are shown in Tables 6.6 -6.10. The performance indices of the indicators and that for the facets of performance prism were found out using Eq. 6.1 and Eq. 6.2.

Table 6.6: Performance evaluation of client category of Kollam Bypass project

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Client's satisfaction for time, cost & quality	0.93	0.83	0.77	Satisfaction = 0.796	22. 11
Profitability of the project	0.87	0.97	0.84		
Appropriateness of the project size & location	0.87	0.9	0.78		
Performance level of the service provided	0.83	0.83	0.69	Strategies = 0.66	18.32
Value for money of the project	0.87	0.9	0.78		
Health, safety & environmental impact of the project	0.7	0.73	0.51		
Competitiveness & transparency in the procurement process	0.93	0.9	0.84	Processes = 0.84	23.33
Effectiveness in communication and coordination between the stakeholders	0.9	0.87	0.78		
Appropriateness of the contract criteria for the project	0.9	0.97	0.87		
Provision of payments on time for completed work by the client	0.97	0.9	0.87		
Favorability and efficiency of the legal framework	0.77	0.73	0.56	Capabilities = 0.72	19.99
Financial stability of the client	0.83	0.8	0.66		
Prior experience of client & EPC contractor	0.97	0.97	0.94		
Client's willingness to active participation in the project	0.9	0.83	0.75	Contribution = 0.585	16.25
Client's contribution to contractor selection	0.7	0.6	0.42		
				Total PI = 3.601	**Total PI = 100 %**

Table 6.7: Performance evaluation of contractor category of Kollam Bypass project

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Contractor's satisfaction for time, cost & quality	0.69	0.8	0.55	Satisfaction = 0.676	20.81
Profitability of the project	0.77	0.83	0.64		
Appropriateness of the project size, design & location	0.89	0.94	0.84		

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Performance level of service provided	0.77	0.8	0.62	Strategies = 0.540	16.63
Value for money of the project	0.8	0.83	0.66		
Health, safety, social & environmental impact of the project	0.49	0.69	0.34		
Effectiveness in communication and coordination between the stakeholders	0.74	0.83	0.61	Processes = 0.605	18.63
Appropriateness of the contract criteria for the project	0.83	0.94	0.78		
Efficiency of risk management (identification, analysis & allocation) in the project	0.71	0.8	0.57		
Appropriateness in the budget and schedule estimates of the project	0.57	0.8	0.46		
Favourability and efficiency of the legal framework	0.57	0.63	0.36	Capabilities = 0.617	18.99
Prior experience of client & EPC contractor	0.91	0.97	0.88		
Reputable developer / strong and good private consortium	0.86	0.77	0.66		
Financial stability of the EPC contractor	0.8	0.71	0.57		
Contractor's willingness to active participation in the project	0.86	0.86	0.74	Contribution = 0.81	24.94
Contractor's overall performance in the project	0.94	0.94	0.88		
				Total PI = 3.248	**Total PI = 100 %**

Table 6.8: Performance evaluation of employee category of Kollam Bypass project

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Employee's satisfaction for time, cost & quality	0.7	0.73	0.51	Satisfaction = 0.837	25.32
Profitability of the project	0.83	1	0.83		
Appropriateness of the project size, design & location	0.97	1	0.97		
Value for money of the project	0.77	0.83	0.64	Strategies = 0.53	16.03
Technology diffusion in engineering, procurement & construction stages	0.63	0.67	0.42		

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Effectiveness in communication and coordination between the stakeholders	0.77	0.8	0.62	Processes = 0.608	18.38
Appropriateness in the budget and schedule estimates of the project	0.7	0.83	0.58		
Extent of site management and supervision	0.87	0.83	0.72		
Claim and dispute management	0.7	0.8	0.56		
Degree of project team work and partnerships	0.77	0.73	0.56		
Efficient TCQ & material management	0.63	0.73	0.46	Capabilities = 0.682	20.62
Presence of skilled working personnel	0.93	0.97	0.90		
Use of advanced planning and scheduling techniques	0.8	0.8	0.64		
Capability for right selection of personnel in the project	0.8	0.87	0.70		
Sufficient availability of good quality construction materials, equipment and skilled labour	0.73	0.97	0.71		
Employee's willingness to active participation in the project	0.77	0.67	0.52	Contribution = 0.65	19.65
Employee's overall performance in the project	0.87	0.9	0.78		
				Total PI = 3.307	**Total PI = 100 %**

Table 6.9: Performance evaluation of supplier category of Kollam Bypass project

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Supplier's satisfaction for time, cost & quality	0.8	0.76	0.61	Satisfaction = 0.765	21.46
Appropriateness of the project size & location	0.92	1	0.92		
Value for money of the project	0.88	0.84	0.74	Strategies = 0.615	17.25
Technology diffusion in material supply and management	0.76	0.64	0.49		
Effectiveness in communication and coordination between the stakeholders	0.88	0.88	0.77	Processes = 0.797	22.36

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
Transportation of materials and equipment on time	0.92	0.96	0.88		
Appropriateness of supply contract criteria	0.88	0.84	0.74		
Efficient TCQ & material management	0.72	0.8	0.58	Capabilities = 0.543	15.23
Favourability and efficiency of the legal framework	0.68	0.72	0.49		
Sufficient availability of good quality construction materials, equipment and skilled labour	0.64	0.88	0.56		
Supplier's willingness to active participation in the project	0.92	0.88	0.81	Contribution = 0.845	23.7
Supplier's overall performance in the project	0.92	0.96	0.88		
				Total PI = 3.565	**Total PI = 100 %**

Table 6.10: Performance evaluation of end-user category of Kollam Bypass project

Performance Indicators	PR	IR	PI for indicators	PI for Facets	Normalized weights for facets (%)
User's satisfaction for time, cost & quality	0.88	0.92	0.81	Satisfaction = 0.755	25.98
Performance level of the service provided	0.8	0.88	0.70		
Value for money for the project	0.8	0.88	0.70	Strategies = 0.595	20.49
Technology diffusion in engineering, procurement & construction stages	0.68	0.72	0.49		
Effectiveness in communication and coordination between the stakeholders	0.64	0.72	0.46	Processes = 0.485	16.69
Effectiveness of facility maintenance and management	0.64	0.8	0.51		
Favourability and efficiency of the legal framework	0.68	0.72	0.49	Capabilities = 0.505	17.38
Knowledge about the project for the users	0.72	0.72	0.52		
User's willingness to the infrastructure use	0.8	0.76	0.61	Contribution = 0.565	19.46
Presence of supporting & understanding community	0.76	0.68	0.52		
				Total PI = 2.905	**Total PI = 100 %**

From the results shown in the above tables, it can be inferred that the total PI of the project is 16.626, which is the sum of the PI values of all the stakeholder categories and the overall performance of the project in percentage is 66.504 %. The client category was the one with highest performance index of 3.601 while the end-user category was the least performing group with a performance index of 2.905. These performance indices were then normalized to get the percentage of performance of the stakeholders. The figure 6.10 shows the variation of percentage of performance of different stakeholders in the project.

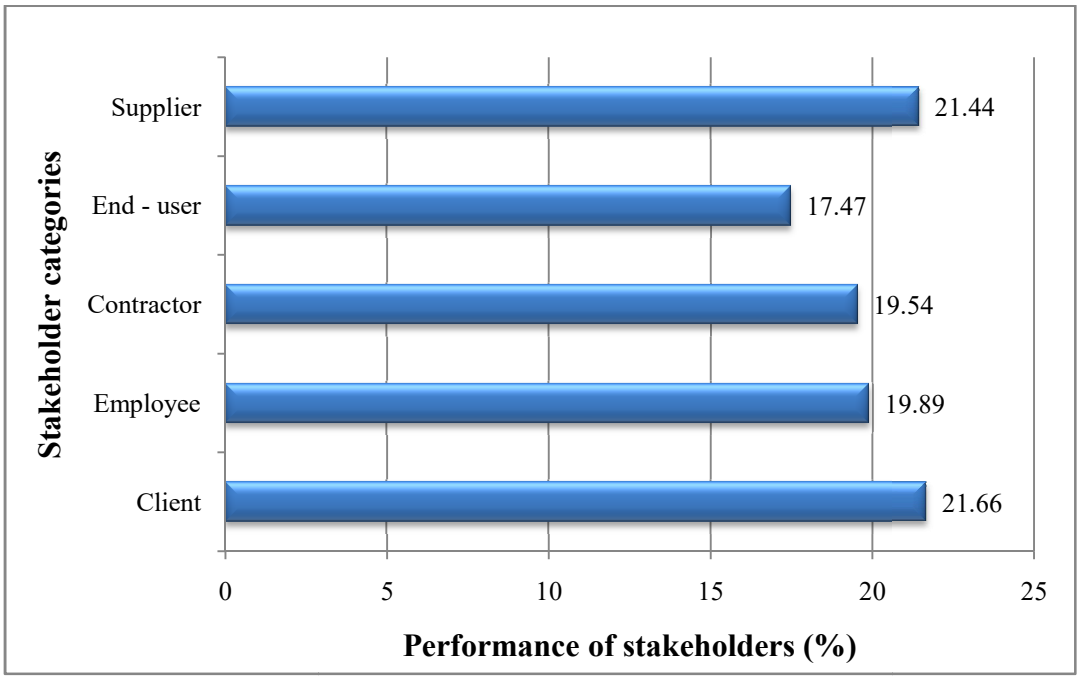

Figure 6.10: Performance of different stakeholders in the Kollam Bypass project

The performance of supplier category was good with a result of 21.44 %. As per the study, the project had encountered with shortage of materials at some point. But still, the suppliers had managed to deliver materials and equipment without causing much delay in the project. The results of contractor and employee categories were showing an average performance in the project (19.54 % and 19.89 % respectively). The contribution of the contractor and the satisfaction of the employees were high whereas all other facets of the two categories were showing average results. This may be due to the large number of activities and issues that the two categories must address. For future projects, they must work on all these facets for better project performance.

6.6 SUMMARY

Kollam Bypass project was selected as the EPC project in Kerala for conducting performance evaluation in this study. The priority weights of the performance indicators obtained through AHP analysis in the previous chapter and the ranks of the indicators for the selected EPC project determined through RII analysis in this chapter have been compared in this section. Most of the stakeholder categories were showing similar rankings for the indicators within which the end-users were showing least variations. The perception of different respondents in responding to the survey questionnaire was found to be having a huge effect on these variations.

The performance evaluation of the Kollam Bypass project was conducted using the Performance Prism framework whose results are also explained in this section. The performance indices of the indicators were obtained using RII rating under prevalence and importance rating. From the results, the client category was found to be outperforming all other stakeholder categories followed by the suppliers and the least performing ones were the end-users. The contractor and employee categories were showing an average performance in the project compared to others.

CHAPTER 7

CONCLUSION

This study aimed to evaluate the performance of EPC projects in Kerala with respect to different aspects of a construction project other than concentrating only on project schedule and budget. From a thorough literature study, the Performance Prism framework was chosen for this purpose as it is framed based on stakeholder perception. The whole study revolves around the performance indicators used in EPC projects and their related analyses. The following were the main conclusions derived from this study:

- 45 important performance indicators relevant for EPC projects in Kerala were identified from an extensive literature review and pilot study.
- Performance Prism framework was chosen for formulating a performance evaluation model for EPC projects using the 45 indicators.
- The ranking of these indicators was determined through AHP analysis in which client's and user's satisfaction, contractor's and supplier's overall performance in the project, performance of the constructed facility, experience of client and contractor and value for money were the highest ranked indicators.
- In order to conduct the performance evaluation of an EPC project, Kollam Bypass project in Kerala was selected. The ranking of the indicators as per the conditions prevalent in the EPC project were determined using RII analysis. The AHP and RII results were used to draw a comparison between the ranks of the indicators for each stakeholder category. Most of the stakeholder categories were showing almost similar rankings with the end-user category having least variations.
- Using RII values under the prevalence and importance ratings, the performance index (PI) of the indicators along with that of the facets of the framework for the project were determined.
- Client category was having highest PI value and end-user category was having the least PI value. The overall performance of the Kollam Bypass project was determined as 66.504 %.

A holistic method for performance evaluation of construction projects has been explored in this study. A performance evaluation model specifically designed for EPC projects concentrated in Kerala has been developed using which the performance of any EPC projects can be obtained in numerical terms. Since the model has been developed based on the Performance Prism framework, it incorporates all the concerns related to the performance of different stakeholders. This study serves as a base for all the performance related studies of EPC projects in Kerala.

REFERENCES

1) Abbasi, O., Noorzai, E., Jafari, K., G., Golbchi, M. (2020), "Exploring the Causes of Delays in Construction Industry Using a Cause-and-Effect Diagram: Case Study for Iran", *Journal of Architectural Engineering*, 26 (3)
2) Alteneiji, K., Alkass, S., Dabous, S, A. (2020), "A review of critical success factors for public–private partnerships in affordable housing", *Internal Journal of System Assurance Engineering and Management*, 11: 1192-1203
3) Badri, M, A. (2001), "A Combined AHP - GP Model for Quality Control Systems", *International Journal of Production Economics*, 72: 27-40
4) Bassioni, H., A., Price, A., D., F., Hassan, T., M. (2004), "Performance Measurement in Construction", *Journal of Management in Engineering*, 20 (2): 42-50
5) Balubaid, M., Alamoudi, R. (2015), "Application of Analytical Hierarchy Process (AHP) to Multi-Criteria Analysis for Contractor Selection ", *American Journal of Industrial and Business Management,* 5: 581-589
6) Choi, K., Jung, I., Yin, Y., Gurganus, C., Jeong, H. D. (2020), "Holistic Performance Evaluation of Highway Design-Build Projects", *Journal of Management in Engineering*, 36 (4)
7) Deli, Y., Zechao, D., Yang, H. (2012), "Application of EFQM Based Excellence Model in PPP Projects ", *Applied Mechanics and Materials, 174: 2957-2965*
8) Deep, S., Simon, L., Asim, M., Rahimzadeh, A., Al-Hamdani, S. (2018), "An Analytical Study of Critical Factors Affecting Contractor Efficiency in Construction Projects in Indian Scenario", *Organization, Technology and Management in Construction*, 10: 1794–1802
9) El-Abidi, K., L., M., Ofori, G., Zakaria, S., A., S., Mannan, A., Abbas, A., F. (2019), "Identifying and Evaluating Critical Success Factors for Industrialized Building Systems Implementation: Malaysia Study", *Arabian Journal for Science and Engineering*, 44: 8761-8777
10) Gunduz, M., Nielsen, Y., Ozdemir, M. (2013), "Quantification of Delay Factors Using the Relative Importance Index Method for Construction Projects in Turkey", *Journal of Management in Engineering,* 29 (2): 133-139

11) Haass, O., Guzman, G. (2020), "Understanding Project Evaluation – A Review and Reconceptualization", *International Journal of Managing Projects in Business*, 13 (3): 573-599

12) Habibi, M., Kermanshachi, S., Safapour, E. (2018), "Engineering, Procurement, and Construction Cost and Schedule Performance Leading Indicators: State-of-the-Art Review", *Construction Research Congress*, pp: 378-388

13) Habibi, M., Kermanshachi, S., Rouhanizadeh, B. (2019), "Identifying and Measuring Engineering, Procurement, and Construction (EPC) Key Performance Indicators and Management Strategies", *Infrastructures*, 4 (2)

14) Kabirifar, K., Mojtahedi, M. (2018), "The impact of Engineering, Procurement and Construction (EPC) Phases on Project Performance: A Case of Large-scale Residential Construction Project", *Buildings*, 9 (1)

15) Kassem, M, A. (2020), "Using Relative Importance Index Method for Developing Risk Map in Oil and Gas Construction Projects", *Journal of Engineering,* 32 (3): 441-453

16) Kurian, S. M., Surendran, A. (2017), "Performance Evaluation of Kollam Bypass Road Construction Kavanad to Kallumthazham Stretch", *International Journal of Engineering Research & Technology*, 6 (10)

17) Liu, J., Love, P. E. D., Davis, P., R., Smith, J., Regan, M. (2014), "Conceptual Framework for the Performance Measurement of Public-Private Partnerships", *Journal of Infrastructure System*, 21 (1)

18) Liu, J., Love, P. E. D., Smith, J., Regan, M. (2017), "A New Framework for Evaluating Public-Private Partnerships", *Advances in Public – Private Partnership, Second International Conference on Public – Private Partnership*

19) Liu, G., Jiang, H. (2019), "Performance Monitoring of Project Earned Value Considering Scope and Quality", *KSCE Journal of Civil Engineering,* 24: 10-1

20) Lop, N., S., Ismail, K., Mohdisa, H., Khalil, N. (2018), "An Effective Approach of Performance Measurement Systems (PMS) for Adoption in Construction Projects", *Journal of Engineering Science and Technology*, 13 (12): 3951-3963

21) Nassar,N., AbouRizk, S. (2014), "Practical Application for Integrated Performance Measurement of Construction Projects", *Journal of Management in Engineering,* 30 (6)

22) Neely, A., Adams, C., Crowe, P. (2001), "The Performance Prism In Practice", *Measuring Business Excellence*, 5 (2): 6-12

23) Neely, A., Adams, C., Kennerley, M. (2005), "The Performance Prism: The Scorecard for Measuring and Managing Business Success", *Cranfield School of Management, Pearson Education,* 1-14

24) Neely, A., Adams, C. (2005), "Performance Prism", *Encyclopaedia of Social Measurement*, 41-48

25) Noorizadeh, A., Peltokorpi, A., Avkiran, N. K. (2019), "Supplier Performance Evaluation in Construction Projects: Challenges and Possible Solutions", *Journal of Construction Engineering and Management*, 145 (4): 04019007

26) Patria, S. W. S., Ahmadi, Suharyo, O. S., Susanto, A. D. (2018), "Performance Assessment of PT. X Automotive Companies Using Performance Prism and Analytical Hierarchy Process (AHP)", *International Journal of Economics and Management Studies,* 5 (8)

27) Prasad, K, V., Vasugi, V. (2019), "Analysis of Causes of Delay in Indian Construction Projects and Mitigation Measures" *Journal of Financial Management of Property and Construction*, 24 (1): 58-78

28) Saaty, T, L. (1990), "How to Make a Decision: The Analytic Hierarchy Process", *European Journal of Operational Research,* 48: 9-26

29) Saaty, T, L. (2008), "Decision Making with the Analytic Hierarchy Process", *International Journal of Services Sciences*, 1(1)

30) Solabannavar, V., Jamadar, B. (2017), "Evaluation and Application of EPC Model to Improve Project Construction", *IOSR Journal of Mechanical and Civil Engineering,* 14 (4): 45-48

31) Thomas, N., Thomas, A. V. (2019), "Critical Analysis of the Success Factors of Public- Private Partnership Projects in Kerala", *NICMAR Journal of Construction Management,* Vol. XXXIV, No. II, April - June 2019, pp: 37-45

32) Wadugodapitiya, K., Sandanayake, Y. G., Thurairajah, N. (2010), "Building Performance Evaluation Model", *CIB World Congress: Building a Better World,* Salford, UK, May 2010, pp:258-269

APPENDICES

APPENDIX A

PILOT SURVEY QUESTIONNAIRE FOR IDENTIFYING EPC PROJECT PERFORMANCE INDICATORS

Given below is the list of 58 performance indicators identified from literature survey for Engineering, Procurement and Construction (EPC) projects in general. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling the questionnaire. Mark your rating against each indicator in the 5- point likert scale according to the significance of each indicator in making EPC projects success. Please respond to each question honestly and accurately. *(1- no significance, 2- slightly significant, 3- moderately significant, 4- very significant, 5- extremely significant)*

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Sl. No.	Performance indicator	Significance of performance indicators				
1	Project knowledge	1	2	3	4	5
2	Demand for project	1	2	3	4	5
3	Project size, location & complexity	1	2	3	4	5
4	Project cost	1	2	3	4	5
5	Project profitability	1	2	3	4	5
6	Project productivity	1	2	3	4	5
7	Health, safety & environmental impact	1	2	3	4	5
8	Level of construction waste & sustainability	1	2	3	4	5

Sl. No.	Performance indicator	Significance of performance indicators				
9	Public client's satisfaction for time, cost & quality	1	2	3	4	5
10	Other stakeholder's satisfaction (concessionaire, contractor, employees, suppliers & users)	1	2	3	4	5
11	Vision and commitment of client & concessionaire	1	2	3	4	5
12	Experience of client, concessionaire & contractor	1	2	3	4	5
13	Experienced manufacturer	1	2	3	4	5
14	Reputable developer / strong & good private consortium	1	2	3	4	5
15	Public client's performance in the establishment of investment environment	1	2	3	4	5
16	Financial stability of client	1	2	3	4	5
17	Financial stability of contractor	1	2	3	4	5
18	Client's delay in payments for the completed work	1	2	3	4	5
19	Change order driven by client	1	2	3	4	5
20	Delay in approval stage	1	2	3	4	5
21	Inaccuracies and deficiencies in budget & schedule estimates	1	2	3	4	5
22	Poor site management and supervision	1	2	3	4	5
23	Sub – contractor's poor management	1	2	3	4	5
24	Delay in decision making in critical situations and emergencies by contractor	1	2	3	4	5
25	Transportation delay of materials & equipments	1	2	3	4	5
26	Sufficient availability of construction materials, equipments & labor	1	2	3	4	5
27	Poor economy conditions (inflation rates, exchange rates, interest rates etc.)	1	2	3	4	5
28	Quality of construction materials & equipments	1	2	3	4	5
29	Appropriateness of concessionaire criteria	1	2	3	4	5
30	Competitive & transparent procurement process	1	2	3	4	5
31	Appropriateness of concession period	1	2	3	4	5
32	Inaccuracy in understanding of contract by the parties	1	2	3	4	5
33	Payment modality in contract	1	2	3	4	5
34	Capability for claim & dispute management	1	2	3	4	5
35	Accidents & incidents	1	2	3	4	5
36	Political support & stability	1	2	3	4	5

Sl. No.	Performance indicator	Significance of performance indicators				
37	Favorable & efficient legal framework	1	2	3	4	5
38	Trust & openness	1	2	3	4	5
39	Supportive & understanding community	1	2	3	4	5
40	Effectiveness of risk management (identification, analysis & allocation)	1	2	3	4	5
41	Effective communication & coordination between stakeholders	1	2	3	4	5
42	Partnering and strategic alliances	1	2	3	4	5
43	Technology diffusion	1	2	3	4	5
44	Flexible financing and tax reduction packages to contractors, manufacturers & suppliers	1	2	3	4	5
45	Efficiency of TCQ & material management	1	2	3	4	5
46	Appropriateness of definition of service need & desired outputs	1	2	3	4	5
47	Innovation for strategic planning, process design, procurement & technology	1	2	3	4	5
48	Leadership from top level management	1	2	3	4	5
49	Skilled management personnel	1	2	3	4	5
50	Degree of project team work & partnerships	1	2	3	4	5
51	Appropriateness of selection of project teams	1	2	3	4	5
52	Advanced planning & scheduling	1	2	3	4	5
53	Effectiveness of facility management	1	2	3	4	5
54	Service performance	1	2	3	4	5
55	Value for money	1	2	3	4	5
56	Stakeholder's overall performance	1	2	3	4	5
57	Stakeholder's willingness to active participation	1	2	3	4	5
58	User's willingness to the infrastructure use	1	2	3	4	5

If you feel that any other indicators other than those mentioned above are relevant for performance evaluation of EPC projects, please write it below along with its rating out of 5.

Thank you for your precious time.

APPENDIX B

B.1. AHP QUESTIONNAIRE FOR CLIENTS OF EPC PROJECTS

Given below is an Analytical Hierarchy Process (AHP) questionnaire meant for the clients of highway projects implemented through EPC mode in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling this questionnaire. The questionnaire consists of three parts in which first part consists of five categories of indicators responsible to the clients that are needed for the performance evaluation of EPC projects. Mark any one indicator among each pair of indicators (Column 1 and Column 2 indicators form a pair) which is more important for the success of EPC projects as per your opinion. For example: In a pair, if column 1 indicator is more important than column 2, then mark the importance of column 1 indicator on the left side of the 9 point rating scale. The second and third part of the questionnaire includes the rating of the five indicator categories and five different stakeholders of EPC projects respectively. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

PART A

If Column 1 element is of more importance than Column 2									Equally important	If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**		**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Indicators that show client satisfaction (3 indicators)																		
Client's satisfaction for time, cost & quality																		Project profitability
																		Appropriateness of project size & location
Project profitability																		Appropriateness of project size & location
Indicators that show client strategies (3 indicators)																		
Value for money																		Performance of service provided
																		Health, safety & environmental impact of the project
Performance of service provided																		Health, safety & environmental impact of the project
Indicators that show client processes (4 indicators)																		
Client's delay in payments for the completed work																		Appropriateness of contract criteria
																		Competitive &

																		transparent procurement process
																		Effective communication and coordination with other stakeholders
Appropriateness of contract criteria																		Competitive & transparent procurement process
																		Effective communication and coordination with other stakeholders
Competitive & transparent procurement process																		Effective communication and coordination with other stakeholders
Indicators that show client capabilities (3 indicators)																		
Experience of client & contractor																		Financial stability of client
																		Favorable and efficient legal framework
Financial stability of client																		Favorable and efficient legal framework
Indicators that show client contribution (2 indicators)																		
Client's contribution to contractor selection																		Client's willingness to active participation

PART B

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Stakeholder's satisfaction																		Strategies of stakeholder
																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Strategies of stakeholder																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Processes of stakeholder																		Capabilities of stakeholder
																		Stakeholder's contribution
Capabilities of stakeholder																		Stakeholder's contribution

PART C

If Column 1 element is of more importance than Column 2									Equally important	If Column 2 element is of more importance than Column 1								Column 2 indicators
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**		**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Clients																		Contractors
																		Employees
																		Suppliers
																		End – users
Contractors																		Employees
																		Suppliers
																		End – users
Employees																		Suppliers
																		End – users
Suppliers																		End – users

Thank you for your precious time

B.2. AHP QUESTIONNAIRE FOR CONTRACTORS OF EPC PROJECTS

Given below is an Analytical Hierarchy Process (AHP) questionnaire meant for the contractors of highway projects implemented through EPC mode in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling this questionnaire. The questionnaire consists of three parts in which first part consists of five categories of indicators responsible to the contractors that are needed for the performance evaluation of EPC projects. Mark any one indicator among each pair of indicators (Column 1 and Column 2 indicators form a pair) which is more important for the success of EPC projects as per your opinion. For example: In a pair, if column 1 indicator is more important than column 2, then mark the importance of column 1 indicator on the left side of the 9 point rating scale. The second and third part of the questionnaire includes the rating of the five indicator categories and five different stakeholders of EPC projects respectively. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail:vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

PART A

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Indicators that show contractor satisfaction (3 indicators)																		
Contractor's satisfaction for time, cost & quality																		Appropriate project size & location
																		Project profitability
Appropriate project size & location																		Project profitability
Indicators that show contractor strategies (3 indicators)																		
Value for money																		Performance of service provided
																		Health, safety & environmental impact
Performance of service provided																		Health, safety & environmental impact
Indicators that show contractor processes (4 indicators)																		
Appropriateness in -																		Appropriateness of contract criteria
																		Efficiency of risk management
																		Effective communication and coordination with

budget and schedule estimates																		other stakeholders
Appropriateness of contract criteria																		Efficiency of risk management
																		Effective communication and coordination with other stakeholders
Efficiency of risk management																		Effective communication and coordination with other stakeholders
Indicators that show contractor capabilities (4 indicators)																		
Experience of contractor& client																		Financial stability of contractor
																		Reputable developer / strong and good private consortium
																		Favourable legal and regulatory framework
Financial stability - of contractor																		Reputable developer / strong and good private consortium
																		Favourable legal and regulatory framework
Reputable developer / strong and good private consortium																		Favourable legal and regulatory framework
Indicators that show contractor contribution (2 indicators)																		
Contractor's willingness to active participation																		Contractor's overall performance

PART B

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Stakeholder's satisfaction																		Strategies of stakeholder
																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Strategies of stakeholder																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Processes of stakeholder																		Capabilities of stakeholder
																		Stakeholder's contribution
Capabilities of stakeholder																		Stakeholder's contribution

PART C

If Column 1 element is of more importance than Column 2									Equally important	If Column 2 element is of more importance than Column 1								Column 2 indicators
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**		**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Clients																		Contractors
																		Employees
																		Suppliers
																		End – users
Contractors																		Employees
																		Suppliers
																		End – users
Employees																		Suppliers
																		End – users
Suppliers																		End – users

Thank you for your precious time

B.3. AHP QUESTIONNAIRE FOR EMPLOYEES OF EPC PROJECTS

Given below is an Analytical Hierarchy Process (AHP) questionnaire meant for the employees of construction companies that undertake EPC mode for highway projects in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling this questionnaire. The questionnaire consists of three parts in which first part consists of five categories of indicators responsible to the employees that are needed for the performance evaluation of EPC projects. Mark any one indicator among each pair of indicators (Column 1 and Column 2 indicators form a pair) which is more important for the success of EPC projects as per your opinion. For example: In a pair, if column 1 indicator is more important than column 2, then mark the importance of column 1 indicator on the left side of the 9 point rating scale. The second and third part of the questionnaire includes the rating of the five indicator categories and five different stakeholders of EPC projects respectively. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

PART A

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Indicators that show employee satisfaction (3 indicators)																		
Employee's satisfaction for time, cost & quality																		Project profitability
																		Appropriateness of project size & location
Project profitability																		Appropriateness of project size & location
Indicators that show employee strategies (2 indicators)																		
Value for money																		Technology diffusion in engineering, procurement & construction stages
Indicators that show employee processes (5 indicators)																		
Appropriateness in budget and schedule estimates																		Proper site management and supervision
																		Claim and dispute management
																		Effective communication and coordination with other stakeholders
																		Degree of project team work and partnerships
Proper site management and supervision																		Claim and dispute management
																		Effective communication and

																		coordination with other stakeholders
																		Degree of project team work and partnerships
Claim and dispute management																		Effective communication and coordination with other stakeholders
																		Degree of project team work and partnerships
Effective communication and coordination with other stakeholders																		Degree of project team work and partnerships
Indicators that show employee capabilities (5 indicators)																		
Skilled working personnel																		Advanced planning and scheduling techniques
																		Efficient TCQ & material management system
																		Capability for right selection of project teams
																		Sufficient availability of good quality construction materials & equipments and skilled labor
Advanced planning and scheduling techniques																		Efficient TCQ & material management system
																		Capability for right selection of project teams
																		Sufficient availability of good quality construction materials & equipments and skilled labor
Efficient TCQ & material management system																		Capability for right selection of project teams
																		Sufficient availability of good

																		quality construction materials & equipments and skilled labor
Capability for right selection of project teams																		Sufficient availability of good quality construction materials & equipments and skilled labor
Indicators that show employee contribution (2 indicators)																		
Employee's willingness to active participation																		Employee's performance

PART B

If Column 1 element is of more importance than Column 2									**Equally important**	**If Column 2 element is of more importance than Column 1**								**Column 2 indicators**
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**		**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Stakeholder's satisfaction																		Strategies of stakeholder
																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Strategies of stakeholder																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution

Processes of stakeholder																		Capabilities of stakeholder
																		Stakeholder's contribution
Capabilities of stakeholder																		Stakeholder's contribution

PART C

If Column 1 element is of more importance than Column 2										**If Column 2 element is of more importance than Column 1**								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Clients																		Contractors
																		Employees
																		Suppliers
																		End – users
Contractors																		Employees
																		Suppliers
																		End – users
Employees																		Suppliers
																		End – users
Suppliers																		End – users

Thank you for your precious time

B.4. AHP QUESTIONNAIRE FOR MATERIAL SUPPLIERS OF EPC PROJECTS

Given below is an Analytical Hierarchy Process (AHP) questionnaire meant for the material and equipment suppliers for construction of highway projects implemented through EPC mode in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling this questionnaire. The questionnaire consists of three parts in which first part consists of five categories of indicators responsible to the suppliers that are needed for the performance evaluation of EPC projects. Mark any one indicator among each pair of indicators (Column 1 and Column 2 indicators form a pair) which is more important for the success of EPC projects as per your opinion. For example: In a pair, if column 1 indicator is more important than column 2, then mark the importance of column 1 indicator on the left side of the 9 point rating scale. The second and third part of the questionnaire includes the rating of the five indicator categories and five different stakeholders of EPC projects respectively. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction supply chain:

PART A

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1									
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Indicators that show supplier satisfaction (2 indicators)																		
Supplier's satisfaction for time, cost & quality																		Appropriate project size & location
Indicators that show supplier strategies (2 indicators)																		
Value for money																		Technology diffusion in material manufacturing and management
Indicators that show supplier processes (3 indicators)																		
Effective communication and coordination with other stakeholders																		Transportation delay of materials and equipments
																		Appropriateness of supply contract criteria
Transportation delay of materials and equipments																		Appropriateness of supply contract criteria
Indicators that show supplier capabilities (3 indicators)																		
Efficient material management system																		Sufficient availability of good quality construction materials & equipments
																		Favourable legal and regulatory framework

Sufficient availability of good quality construction materials & equipments																		Favourable legal and regulatory framework
Indicators that show supplier contribution (2 indicators)																		
Supplier's willingness to active participation																		Supplier's overall performance in the project

PART B

If Column 1 element is of more importance than Column 2										**If Column 2 element is of more importance than Column 1**								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Stakeholder's satisfaction																		Strategies of stakeholder
																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Strategies of stakeholder																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Processes of																		Capabilities of

stakeholder																		stakeholder
																		Stakeholder's contribution
Capabilities of stakeholder																		Stakeholder's contribution

PART C

If Column 1 element is of more importance than Column 2										**If Column 2 element is of more importance than Column 1**								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Clients																		Contractors
																		Employees
																		Suppliers
																		End – users
Contractors																		Employees
																		Suppliers
																		End – users
Employees																		Suppliers
																		End – users
Suppliers																		End – users

Thank you for your precious time

B.5. AHP QUESTIONNAIRE FOR END-USERS OF EPC PROJECTS

Given below is an Analytical Hierarchy Process (AHP) questionnaire meant for the end-users of highway projects constructed through EPC mode in Kerala. We recognize that you are with relevant knowledge and understanding about construction projects. We request you to help us by filling this questionnaire. The questionnaire consists of three parts in which first part consists of five categories of indicators responsible to the end – users that are needed for the performance evaluation of EPC projects. Mark any one indicator among each pair of indicators (Column 1 and Column 2 indicators form a pair) which is more important for the success of EPC projects as per your opinion. For example: Ina pair, if column 1 indicator is more important than column 2, then mark the importance of column 1 indicator on the left side of the 9 point rating scale. The second and third part of the questionnaire includes the rating of the five indicator categories and five different stakeholders of EPC projects respectively. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Respondent designation:
2. Experience in the field of working:

PART A

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 Indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Indicators that show end-user satisfaction (2 indicators)																		
User's satisfaction for time, cost & quality																		Performance of service provided
Indicators that show end-user strategies (2 indicators)																		
Value for money																		Technology diffusion in engineering, procurement & construction stages
Indicators that show end-user processes (2 indicators)																		
Effective communication and coordination with other stakeholders																		Effectiveness of facility management
Indicators that show end-user capabilities (2 indicators)																		
Project knowledge																		Favourable legal and regulatory framework
Indicators that show end-user contribution (2 indicators)																		
User's willingness to the infrastructure use																		Supporting& understanding community

PART B

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Stakeholder's satisfaction																		Strategies of stakeholder
																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Strategies of stakeholder																		Processes of stakeholder
																		Capabilities of stakeholder
																		Stakeholder's contribution
Processes of-Stakeholder																		Capabilities of stakeholder
																		Stakeholder's contribution
Capabilities of stakeholder																		Stakeholder's contribution

PART C

If Column 1 element is of more importance than Column 2										If Column 2 element is of more importance than Column 1								
Column 1 indicators	**Extremely**	**Very strongly to extremely**	**Very strongly**	**Strongly to very strongly**	**Strongly**	**Moderately to strongly**	**Moderately**	**Equally to moderately**	**Equally important**	**Equally to moderately**	**Moderately**	**Moderately to strongly**	**Strongly**	**Strongly to very strongly**	**Very strongly**	**Very strongly to extremely**	**Extremely**	**Column 2 indicators**
	9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Clients																		Contractors
																		Employees
																		Suppliers
																		End – users
Contractors																		Employees
																		Suppliers
																		End – users
Employees																		Suppliers
																		End – users
Suppliers																		End – users

Thank you for your precious time

APPENDIX C

C.1. QUESTIONNAIRE FOR PERFORMANCE EVALUATION OF ENGINEERING, PROCUREMENT AND CONSTRUCTION PROJECTS – CLIENT

This questionnaire is aimed at the implementation of performance evaluation of highway projects delivered through Engineering, Procurement and Construction (EPC) projects in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact: Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Given below are some of the performance indicators as identified from literature. Kindly mark your rating against each indicator in the 5- point likert scale according to the effect of the factor on the project performance. **(5- Very high score, 4- High score, 3- Moderate score, 2- Low score, 1- Very low score)**

Sl. No.	Performance Indicator	How do you rate the prevalence of this indicator in the project?	How do you rate the importance of this indicator on the project performance?
1	Client's satisfaction for time, cost & quality	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
2	Profitability of the project	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
3	Appropriateness of the project size & location	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*

4	Performance level of the service provided	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
5	Value for money for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
6	Health, safety & environmental impact of the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
7	Competitiveness & transparency in the procurement process	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
8	Effective communication and coordination between stakeholders	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
9	Appropriateness of the contract criteria for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
10	Provision of payments on time by the client for completed work	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
11	Favorability and efficiency of the legal framework	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
12	Financial stability of the client	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
13	Prior experience of client & EPC contractor	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
14	Client's willingness to active participation	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
15	Client's contribution to contractor selection	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*

Thank you for your precious time

C.2. QUESTIONNAIRE FOR PERFORMANCE EVALUATION OF ENGINEERING, PROCUREMENT AND CONSTRUCTION PROJECTS – CONTRACTOR

This questionnaire is aimed at the implementation of performance evaluation of highway projects delivered through Engineering, Procurement and Construction (EPC) projects in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Given below are some of the performance indicators as identified from literatures. Kindly mark your rating against each indicator in the 5- point likert scale according to the effect of the factor on the project performance. **(5- Very high score, 4- High score, 3- Moderate score, 2-Low score, 1- Very low score)**

Sl. No.	Performance Indicator	How do you rate the prevalence of this indicator in the project?	How do you rate the importance of this indicator on the project performance?
1	Contractor's satisfaction for time, cost & quality	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
2	Profitability of the project	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
3	Appropriateness of the project size & location	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*

4	Performance level of the service provided	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
5	Value for money for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
6	Health, safety & environmental impact of the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
7	Effectiveness in communication and coordination between the stakeholders	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
8	Appropriateness of the contract criteria for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
9	Efficiency of risk management (identification, analysis & allocation)	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
10	Appropriateness in the budget and schedule estimates	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
11	Favorability and efficiency of the legal framework	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
12	Prior experience of client & EPC contractor	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
13	Reputable developer / strong and good private consortium	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
14	Financial stability of the EPC contractor	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
15	Contractor's willingness to active participation	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
16	Contractor's overall performance	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*

Thank you for your precious time

C.3. QUESTIONNAIRE FOR PERFORMANCE EVALUATION OF ENGINEERING,PROCUREMENT AND CONSTRUCTION PROJECTS – EMPLOYEE

This questionnaire is aimed at the implementation of performance evaluation of highway projects delivered through Engineering, Procurement and Construction (EPC) projects in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering,Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Given below are some of the performance indicators identified from literature. Kindly mark your rating against each indicator in the 5- point likert scale according to the effect of the factor on the project performance. **(5- Very high score, 4- High score, 3- Moderate score, 2- Low score, 1- Very low score)**

Sl. No.	Performance Indicators	How do you rate the prevalence of this indicatorin the project?	How do you rate the importance of this indicator on the project performance?
1	Employee's satisfaction for time, cost & quality	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
2	Profitability of the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
3	Appropriateness of the project size & location	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*

4	Value for money for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
5	Health, safety & environmental impact of the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
6	Effectiveness in communication and coordination between the stakeholders	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
7	Appropriateness in the budget and schedule estimates	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
8	Degree of site management and supervision	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
9	Claim and dispute management	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
10	Degree of project team work and partnerships	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
11	Efficient TCQ & material management	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
12	Presence of skilled working personnel	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
13	Use of advanced planning and scheduling techniques	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
14	Capability for right selection of project teams	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
15	Sufficient availability of good quality construction materials, equipments and skilled labour	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
16	Employee's willingness to active participation	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
17	Employee's overall performance	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*

Thank you for your precious time

C.4. QUESTIONNAIRE FOR PERFORMANCE EVALUATION OF ENGINEERING, PROCUREMENT AND CONSTRUCTION PROJECTS – SUPPLIER

This questionnaire is aimed at the implementation of performance evaluation of highway projects delivered through Engineering, Procurement and Construction (EPC) projects in Kerala. We recognize that you are a professional with rich expertise in the field of construction. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering, Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Given below are some of the performance indicators as identified from literature. Kindly mark your rating against each indicator in the 5- point likert scale according to the effect of the factor on the project performance. **(5- Very high score, 4- High score, 3- Moderate score, 2- Low score, 1- Very low score)**

Sl. No.	Performance Indicator	How do you rate the prevalence of this indicator in the project?	How do you rate the importance of this indicator on the project performance?
1	Supplier's satisfaction for time, cost & quality	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
2	Appropriateness of the project size & location	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*

3	Value for money for the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
4	Health, safety & environmental impact of the project	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
5	Effectiveness in communication and coordination between the stakeholders	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
6	Transportation of materials and equipments on time	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
7	Appropriateness of supply contract criteria	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
8	Efficient TCQ & material management	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
9	Favourability and efficiency of the legal framework	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
10	Sufficient availability of good quality construction materials, equipments and skilled	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
11	Supplier's willingness to active participation	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*
12	Supplier's overall performance	1 2 3 4 5	*Very low/ Low/ Moderate/ High/ Very high*

Thank you for your precious time

C.5. QUESTIONNAIRE FOR PERFORMANCE EVALUATION OF ENGINEERING,PROCUREMENT AND CONSTRUCTION PROJECTS – END USER

This questionnaire is aimed at the implementation of performance evaluation of highway projects delivered through Engineering, Procurement and Construction (EPC) projects in Kerala. We recognize that you are a professional with rich expertise in your field of working. We request you to help us by filling the questionnaire. Please respond to each question honestly and accurately.

I assure you that your response will be kept confidential and it will be used strictly for academic / research purposes.

For any queries/ suggestions regarding the research, please contact:
Vani Mohan V, P. G. Scholar, Dept, of Civil Engineering, TKM College of Engineering,Kollam
E-mail: vanimohanv.1998@gmail.com

GENERAL INFORMATION:

1. Organization name:
2. Respondent designation:
3. Experience in construction industry:

Given below are some of the performance indicators as identified from literature. Kindly mark your rating against each indicator in the 5- point likert scale according to the effect of the factor on the project performance. **(5- Very high score, 4- High score, 3- Moderate score, 2- Low score, 1- Very low score)**

Sl. No.	Performance Indicator	How do you rate the prevalence of this indicator in the project?	How do you rate the importance of this indicator on the project performance?
1	User's satisfaction for time, cost & quality	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*

2	Performance level of the service provided	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
3	Value for money for the project	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
4	Health, safety & environmental impact ofthe project	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
5	Effectiveness in communication and coordination between the stakeholders	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
6	Effectiveness of facility maintenance and management	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
7	Favorability and efficiency of the legal framework	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
8	Knowledge about the project for the users	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
9	User's willingness to the infrastructure use	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*
10	Presence of supporting & understanding community	(1) (2) (3) (4) (5)	*Very low/ Low/ Moderate/ High/ Very high*

Thank you for your precious time

LIST OF PUBLICATIONS

- Mohan, V. and Thomas, A., V. (2022). "Performance Evaluation Model for Engineering, Procurement and Construction Projects Using Performance Prism Framework", *Proceedings of 2nd International Conference on Recent Trends in Engineering, Technology and Management, ICRETM 2022,* Christ The King Engineering College, Coimbatore, 6th & 7th May 2022