“Analysis Of Variables Of Quality In Construction”

A Thesis

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CERTIFICATE

This is to certify that the work which is being presented in the seminar titled **"Analysis Of Variables Of Quality In Construction"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "**Construction Management**" and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by ROHIT SHARMA (Enrolment No. 152611) during a period from July 2016 to December 2017 under the supervision of **Dr. ASHOK KUMAR GUPTA** professor and Head of Department, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. And **Mr. AAKASH GUPTA,** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

Construction industry is ever-growing in nature, with focus on development the quality of production needs to be carefully tacked, and as the quality of a construction project simply does not depend on one person or one method, all the factors are needed to be handled carefully to provide customer with best quality standard as possible. In country like India where the pace of construction is very fast and the need of quality construction is present, somehow due to competition in the workplace and in the market, the costs have to be reduce to attract more and more customers. This leads to deterioration of the quality of construction. The lack of quality material and quality process and eventually quality management results in cheaper but unsafe constructions.

The study is focused on finding the variables that affect the quality in both good and the bad way. Starting with a hypothesis that describes the relation between the direct and the indirect variables of construction and the quality of construction. The first stage is about finding all the possible factors that affect the quality, then directing towards the magnitude and scale of these variables on the quality, finally this study will discover the hidden variables that are responsible for deterioration of quality in the first stage itself. Meanwhile, the factors that affect quality in a positive way will be unveiled.

Construction management is closely bonded to quality management. As in this era of construction, bad quality not only leads to defame of the engineer but in cases of negligence, it may also result in damage to wellbeing of the occupants, loss of capital investment, material and machine wastage. The second stage of the study i.e. the evaluation of the variables will then help us in better understanding about the steps that shall be taken to improve the quality in construction without affecting the other project variables.

The study will propagate in holistic manner and all the findings shall be entertained and discussed to their very extent. Finally the analysis will be able to conclude the hypothesis related to the quality and the variables.

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CHAPTER 1
INTRODUCTION

1.1 General

India is emerging as one of the world's most rapidly developing country, and with agriculture and construction as top most employment generating sectors. Construction industry plays a vital role in the economic growth of any country and is one of the major industry determining the development of any nation. Indian construction industry has a workforce of about 32 million and the market in construction has worth of INR 2,48,000 crores up to 2015, construction sector is viewed as a service sector. It also provides growth incentive to various industries like wood, steel, cement, iron, fabrication etc. whose combined value more than INR 1, 92,000 crores according to the newest data.

Construction sector is leading helper in improving GDP of India, employment, job and service provider as well, construction industry is unquestionably the fastest growing sector, but because of to so many companies and employees fighting for customer, production, market and position, there are some factors that governs the success of the firm, some of them being "quality, cost, and time". If all three are perfectly synced up then the company is definite to gain position and profits, and any one of the factor if fluctuates, it imbalances the other two too. This study focusses on quality aspect of construction management.

For example if a contractor is about to construct a residential apartment for INR 10 lakh, within a year and for minimum cost. He might end up hiring all labor instead of machines as the cost of labor is very less when compared to that of a machine for less work. For such a low budget the strength of apartment would be week and it might not be good looking, also all the works, be it major or minor one single contractor will handle it to increase the profitability. On the other hand, if the cost is increased, the contractor might use help from specialist contractors for better quality of work, he shall also use good quality material and machines over labour, new and latest machines and innovations and the project shall be completed on time. This explains the effect of cost and time on quality of project, similarly education leadership and many more factors affect the overall quality of project. All the variables that directly or indirectly affect the quality of construction can be classified into categories.

The variables affect the quality in many ways; some factors directly affect the quality as cost is directly related to quality. More the cost invested more is the chance of attaining a desired level of quality. On the other hand, if a person is not well educated, he might be able to provide good construction work but the quality level may not be up to the mark. That leads to a question "what is the need of quality in construction?"
Quality is viewed in two different perspectives, one according to the customer and one according to the contractor, for public works, the customer is public and there comes in play "cost to benefit". The demands of the customer affect the working of the contractor but not the other way around.

1.2 Clients Perspective On Quality

According to many previous researches carried out in this field, the client's perspective on quality is the standard of quality. It is clear that the contractor will not increase the quality standards on his own given the usual constraints. However, a poor workmanship can degrade the quality but we will discuss that later. The design of the project should comply with the effectiveness and the compatibility with the local requirements in both pre and post construction stages.

To understand the perspectives of the clients about the quality, tenders are be called as the "*Guiding Maps*". The logic behind the tenders is to focus on two main objectives that are:

- *Value for money*- it means the best available work in the given money for the client. It creates a sense of how well the service or the product is and the level of satisfaction it creates in the customer. As all construction works are in one way or the other different from the other, they have different degrees of value for money.
- *Fit for purpose- it* means the degree to which the service or construction satisfies the requirement ad defined, as early as the briefing stage.

The constructor's perspective however varies a little bit form the owner's perspective in certain manner as the physical and groundwork is to be carries out by the constructor and not the client. The quality here is defined by the quality of the material and the process involved. The constructor's perspective is as follows.

- *Client's satisfaction:* the matter of concern for the constructor is the client's satisfaction towards the construction. This can be divided into measurable and subjective parameters that includes design features such as design features and finishing.

1.3 Need For Quality

Attaining quality in construction sector had been a necessity since beginning of construction works, each year huge amounts of capital, and great expenditure in terms of time money and material are invested just for repair and retrofitting the bad quality work. Quality is more of a necessity rather than a need. Quality also relates to the cost, if the quality management were not proper in a firm then the work done would compromise with the quality of the structure, be it in terms of strength, aesthetics, or structural anomalies. The cost and resources utilized in this situation shall be far more than the resources and cost during the construction stage if quality management was present and properly followed. This all depends upon the customer, of the customer wants to save money by disregarding the quality management process; the contractor will not put extra effort in the same. According to Latham (1996), the customer is the basis of the construction project and the aim of the project is the expectations of the customer. The quality of the project is determined by

- Pleasing look
- Supported by worthwhile guarantees
- Reasonable running costs
- Satisfactory durability
- Free from defects on completion
- Delivered on time
- Fit for the purpose
- Value for money
- The best material quality for given money
- The best look for given money

Quality is referred in different contexts for comparison purposes, quantitative purposes and fit for purpose. During comparison, the degree of excellence of the comparative products is ranked and relative basis that can be referred to as grade of the product. The quantitative purpose beholds the manufacturing of the product phase. Finally, the fit for purpose determines the aim of the project and the degree up to which, the project performs according to its aim. The three references of quality clearly defines the need of quality in construction work as, for upgradation of a system or process, for purpose of better cost to public and cost to benefit ratios.
The poor quality in construction is a very frequently occurring phenomenon.

1.4 Need For Study

Quality in construction is important as for residential and commercial or any other purpose the public is under a roof or under loads, a small error in design or construction can lead to drastic results. This being one of the main reason that quality is absolute necessity in construction industry. The need of study is ever-present because construction management deals with managing all the construction aspects like quality, cost, time and safety. Talking about the construction sector there is a huge customer demand and the contractor who promises the best quality work to the client satisfies the demand. The large companies have a very well developed quality management programs. However, in the case of the small contractors, quality is not given importance and that eventually leads to below average quality work and less growth of the small sector. This study focusses on finding the variable that affect quality in small sectors like pity contractors and individual contractors, laborers etc. and probably finding economical ways to introduce quality to the work, in rural areas where fast construction is about to start, a small change in procedure can be a deciding factor regarding good quality work or poor quality workmanship.

Quality in construction is important as it involves quality work in planning, designing, construction, estimating and many more works involved in the process. Neglecting quality in any of the stages can lead to unwanted results and poor work grade. Implying quality is neither time consuming nor cost increasing process but neglecting the quality per stage increases the time of construction if any problem arises at later stages and to repair or retrofit the cost eventually increases. Many standards provide guidelines to show the working procedure to ensure quality and safety, but small contractors often ignore the codes and works by ongoing practices and rule of thumb.

Finding the variables that affect the quality and analyzing the trends, finding out relations will give civil workers better idea about what kind of contractor to hire and what kind of work is to be expected given the four qualities discussed in the paper. The relations and fuzzy logic will help in determining whether how much of resources in terms of the variables are required to achieve the satisfactory level of quality.

1.5 Objectives of Study

1. To study previous researches related to quality.
2. To find out the factors responsible for level of quality.
3. To derive the critical factors from the obtained factors.
4. To design a questionnaire based upon the factors.
5. To distribute and personally conduct the questionnaire survey.
6. To convert the responses of the survey in to values that are required for further analysis.
7. To perform the basic ANOVA test on the output.
8. To perform ad hoc test if possible after obtaining ANOVA result.
9. To apply FUZZY LOGIC approach.
10. To discuss the butterfly affect in quality of construction.
11. To conclude the results and perform the practical work if possible.
12. To suggest changes, define terms and future scope of the work.

1.5.1 To Study Previous Researches Related To Quality

A set of research papers has been considered in the study to

a) Understand the scope of the project.
b) Determine the work that can be carried out and has not been done before.
c) To determine the factors that are responsible directly or indirectly for the quality in construction.
d) To study the approaches and the methodology to be followed in similar or relatable projects.
e) To understand the implementations of the work in practical life and in construction
f) To know the ways to help the contractors in obtaining quality in construction.

The research papers included in the research has been listed in the references section of this paper. Studying the researches has proven to be one of the best ways to know the topic as researchers and students from all around the globe have encountered different sets of problems and have different opinions related to same problems. As construction, process is one of the most complex process. With always new set of difficulty levels per stage and different solutions to all problem, it is hard to get a universal standard to obtain quality, although the standards are there and described to get the maximum level of quality, productivity and specification. However, due to uncertainties and contingencies appearing every now and then all the codes prove to be less helpful to a certain level.

According to many researches the ISO have been helpful and according to some the standards have almost no or negligible effect. According to the author of this paper, this all is because of the variation of works, processes and methodology and problems in construction industry.

1.5.2 To Find Out The Factors Responsible For Level Of Quality

From the research papers it has been concluded that almost every process gone wrong is an act of human negligence and in some cases the fault of the machinery. The faults of machines can also be seen and attended to beforehand via means of inspections. Furthermore about 90 factors have been found from various research papers and studies and conferences related to construction

process. It is a point to be noted that not construction work does not simply consists of "construction". It is a combination of construction, maintenance repair and retrofitting and it merges with concrete , wood, metal, glass and many more material that combines to build a QUALITY residence or project.

The factors found out are listed in the table in the methodology chapter.

1.5.3 To Derive The Critical Factors From The Obtained Factors

After collecting the factors and categorizing them into classes. These classes for the rural area are

1. Management
2. Contractor
3. Workforce
4. Material

These classifications are important to relate the problems that occur in spite of following the IS CODES and still not being able to obtain the desired quality due to errors. The classification can easily define the errors and mistakes and the problems related to the department. Among four departments, many factors lay common. In addition, these are termed as critical factors; the other factors remaining are termed as noncritical factors. The critical factors are of greater importance than the noncritical factors because, of these critical factors directly affect the quality and are inter-related. The inter-relation will be discussed later in the study.

The critical factors obtained are as follows,

1. Control
2. Commitment
3. Communication
4. Cost
5. Customer
6. Degree of innovation
7. Employee empowerment
8. Experience
9. Inspection
10. Planning
11. Prequalification of contractor
12. Profitability

1.5.4 To Design A Questionnaire Based Upon The Factors

The critical factor helps in designing a very effective questionnaire specifically focused on obtaining a specific set of responses that is both original and simple to understand with just the information needed to work with. The questionnaire is required in this study to find the responses of the workers and respondents regarding the variables. In addition, it shows a theoretical approach towards the trends that are being followed in the quality in construction.

A questionnaire of 20 questions is proposed with following types of question.

a) Multiple Choice Question
b) Statement Oriented Question.
c) Multiple Answer Question
d) Rating Type Question.

e) Crisp Questions.

1.5.5 To Distribute And Personally Conduct The Questionnaire Survey.

The distribution and conducting the survey is a very long and tedious process as the authenticity of the responses cannot be guaranteed so the questionnaire is designed to obtain the authentic results by distribution of values of the responses; the distribution will be discussed later.
The target responses were around 20- 25 and 30 survey papers were distributed and conducted, the visible altered papers were rejected and only the authentic papers are recorded in the research. The authenticity of the responses is a critical point and perhaps only critical point in the survey conduction part of the research. As fake and altered or sugar coated responses will alter the analysis part of the project. Therefore, the authenticity of the responses was given utmost importance.

1.5.6 To Convert The Responses Of The Survey In To Values That Are Required For Further Analysis.

After obtaining the survey back, the responses are to be converted into values that can be used in the analysis process, as the mathematical analysis can only be carries out on numbers and the numbers cannot lie. Every response was designed with a specific score related to

a) Cost
b) Experience
c) Planning
d) Time

This response pattern was termed at C.E.P.T analysis and as these factors are directly related to quality of construction and interrelated to each other, a term "interCEPT" has been coined.
InterCEPT can be defined as the fuzzy relation between the Cost, Experience, Planning and Time. The fuzzy relation will be discussed later in the study.

1.5.7 To Preform The Basic ANOVA Test On The Output

ANOVA stands for analysis of variables and as it has been established that this study is focused on the analysis of the variables that affect the quality, ANOVA is the best and primary method to test out if the factors really have any role in the quality or not. Performing simple ANOVA test to the research will clearly define if the factors affect the quality are of equal importance or if there is a fuzzy logic between the variables, the ANOVA method will stop after stating the result, t does not tells us about the extent of the effect of the factors.

1.5.8 To Perform Ad Hoc Test If Possible After Obtaining ANOVA Result

The additional tests to confirm and find out the effect of the variable on each other is done through the ADHOC tests of the ANOVA method. The anova method is useful to prove a hypothesis, like does the variables affect the quality or not? However, the ad-hoc tests are further steps to determine the relation present if any. Provided that the variables affect the quality and might or might not be related to one another.
Some of the common ad-hot tests to anova are "t-test", "f-test", regression analysis using anova and many more. Usually these tests can be easily and efficiently performed by the SPSS software, which will be used in this study.

1.5.9 To Apply Fuzzy Logic Approach.

Fuzzy logic states the extent of a variable that is considered. If the normal analysis tells that the quality in construction is being affected by any variable, the fuzzy logic can tell us the extent to

which the variable affects the quality. That is, fuzzy logic can convert a “yes or no” into a degree of “being or not being followed”. The fuzzy logic approach is also critical in the second stage of the project as for contribution to society it is necessary to know the details and extend of the trend being followed in the construction process.
The approach will be discussed later in the study.

1.5.10 To Discuss The Butterfly Effect In Quality Of Construction.

The butterfly effect is a very simple hypothesis that states that "a very minute change in a process, can lead to very dramatic change in the whole process". May that be a butterfly flapping its wings that leads to a tornado.

The butterfly affect is considered in the study, because after obtaining the result from the analysis it is not necessary to change the working process but just a fragment of the attitude towards the working or the very minute working culture. It is assumed that a small positive change in the method can contribute to the overall quality of the project.

1.5.11 To Conclude The Results And Perform The Practical Work If Possible.

The results and the conclusions are discussed in respective chapters of the study. It has been observed so far that the factors that affect the quality based upon the delta values can be improved to obtain even greater quality standards. It is already established that quality means different to different people and no standard can satisfy all the required standards to the fullest, it is in the hands of the contractors and the workmen to improve or degrade the expectations. The papers has proposed a way to improve the quality with keeping in mind the cost and time respectively.

1.5.12 To Suggest Changes, Define Terms And Future Scope Of The Work

Every research is unique in its own way and is carried out for betterment of the people, with a scope of contribution to society. Similarly, this study is focused on improving the quality standards of rural construction. India being such a vast country and marching towards development, the urban and metro cities have a very fast pace of development and the standards of quality according to the customer can be obtained wit help of large and unlimited workforce along with large capital investments, the same cannot be applied to rural areas.

The changes and scope has been discussed in the respective chapters.

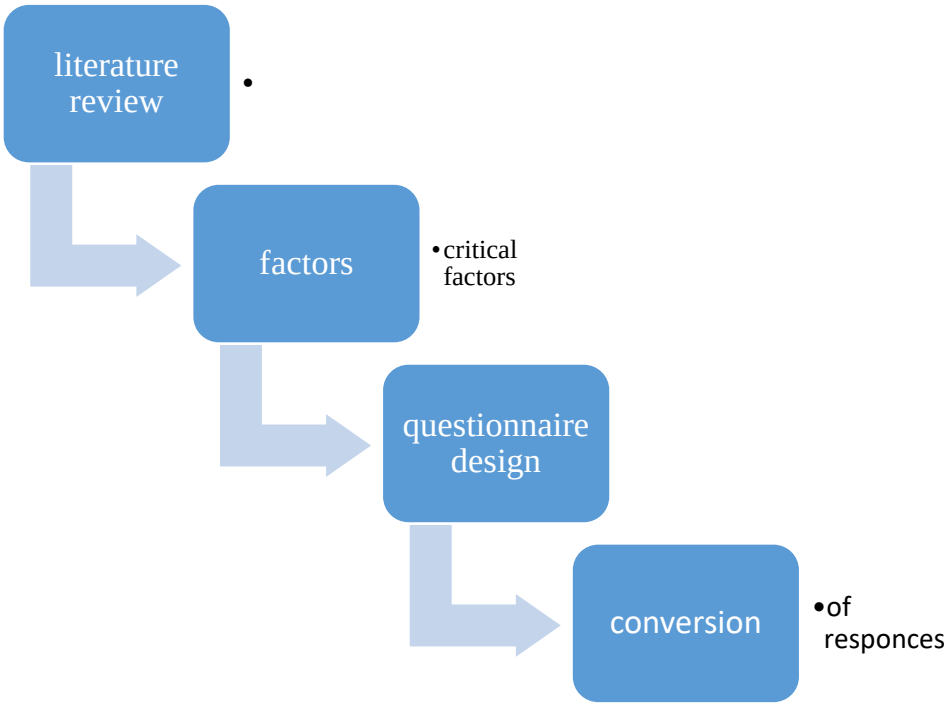


Figure 1: Objective Chart

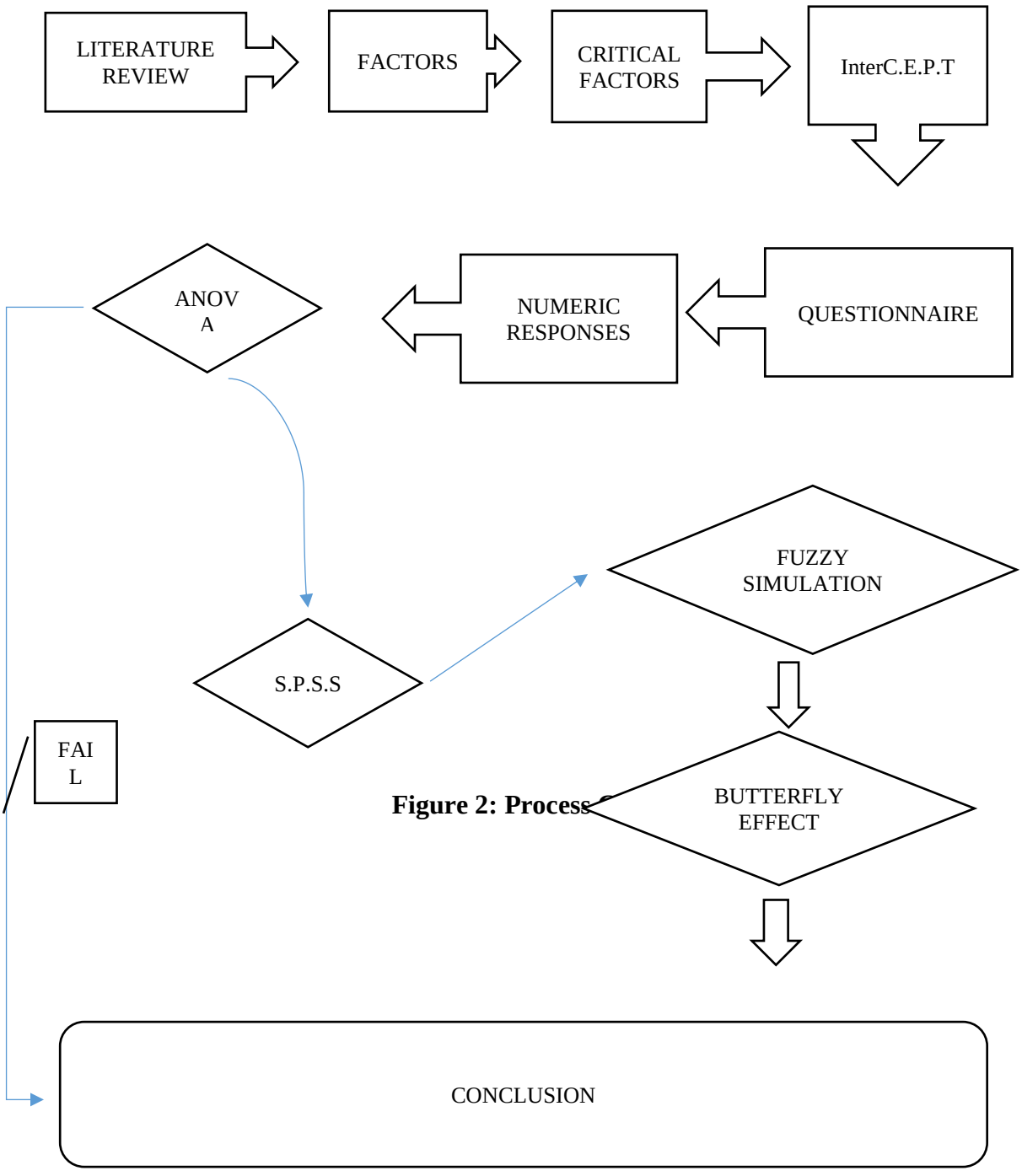


Figure 2: Process C

1.6 Scope Of Study

Quality in construction is a very vast topic; it includes quality assurance, planning, inspection, control and quality audits. All these steps are necessary to attain the desired level of quality. The steps mentioned to attain desired level of quality are already discussed in the previous research papers and research works. The studies that are not yet been carried out are, related to analyze the variables that affect the quality by a series of steps and software in a systematic and progressive approach. This will give concrete vision on the present trends of quality management and control. The study is to analyze the trends in quality and for the purpose of the study a questionnaire is developed, this questionnaire is itself based on the categorized variables that affect the quality. Further through the outcomes of the questionnaire the variables are further to be classified and analysis using ANOVA, SPSS SOFTWARE are proposed, it is also feasible to imply fuzzy logic to the variables. The results from this study will show a fashion of working of contractors and workers in rural and urban small construction industry and will help in improvement of this small sector.

CHAPTER 2.

LITERATURE REVIEW

2.1 Introduction

Providing quality is not a difficult task if the procedures are followed correctly, there are numerous ways to provide quality to a project and either practical works discovered these, by hit and trial methods or either by studying literatures of previous authors and finding important points or by finding loopholes in the theories and the assumptions. Literature review helps a study in numerous ways like:

1) Appraisal and difference in the views of authors
2) Combination of similar authors
3) Highlighting archetypal studies
4) How case studies related to topics and different studies

The aim of literature review is to clearly find a problem and limit it as well as to place the study, to check if it is an original work or has been carries out before. For the purpose of literature review, some of the research journals and discussions are explained below and their contribution to the project is clearly a salient feature of this study.

2.2 Study Of Quality Management In Construction Industry By D. Ashok Kumar [1]

The main objectives of the study were to examine the adoption and enactment of quality management system in construction industry, besides with determination of main factors that are most likely affecting quality of construction at execution stage. Further, the objectives include creating quality awareness at low level and to minimize indirect costs of project. The project works on a "measurement methodology" for customer satisfaction and continuous improvement.

The study includes "plan-do-check-action "cycle for quality management a survey is carried out bases upon which a pilot survey is carries out. The study then identifies main factors affecting quality as limitations and training policies. These limitations can be further expanded as limitations in finance, communication, labor and wage, weather, building plan and construction details, material and equipment, time, construction methodology, rule and regulations. Furthermore, the study collects data from a questionnaire. The important points from this paper are

1) Quality management in design and construction are the most important for project.
2) Clients require service quality and faster building and innovations.
3) Quality = performance / expectations.

2.3 A Study On The Factors Affecting Total Quality Management In -The Saudi Arabian Construction Industry By Umair Mazher, Behrooz Gharleghi, Benjamin Chan Yin Fah [2]

The author collects data about quality control, assurance and inspection. The paper then finally discusses the state of total quality management in Saudi Arab. The study is based on hypothesis that the QMS in Saudi Arab cannot bring higher quality of construction work. The industries adopting quality assurance methods cannot have positive influence on the quality and so on.

The study uses S.P.S.S (software) for the analysis of the data. The study collects quality definitions by various authors According to Dale & Bunney, (1999), quality inspection is a set of activities which include measuring, examining, testing, gauging one or more characteristics of the products and services and comparing all the results with specified requirements in order to access each characteristic through determining conformity. As reported by Juran (2008), quality inspection contributes to quality improvement by experienced employees. Measurement, examination can be handled more efficiently due to experienced employee implemented. Skilled staffs help to organization towards managing quality improvement ideology in the process of production. Quality inspection equips work process with level of activities and techniques of quality improvement.

As noted by Dale et al, (1994) quality assurance emphasizes on defect prevention, focuses on the prevention of the production of non- conforming products in order to provide the confidence of organizational outputs, and ensures meeting customer satisfaction. Moreover, it is aimed to control quality at all stages of production that are designed to ensure that the final product and service meets customer expectations

As reported by Besterfield (2008), employee training plays an important role for organizations so as to improve employee skills and their work flow, as well as accelerating organizational performance that provide quality and customer satisfaction.

As noted by Ramezani & Gharleghi (2013), employees and management have to work as a team with all departments, integrated together to achieve required outcome of the quality management in order to provide value for organization and high quality outputs

Furthermore, the research is based on 4 hypothesis

A) Quality management in Saudi Arabia cannot bring higher degree of quality.
B) Industries in Saudi Arabia following quality procedures cannot show positive results.
C) Industries adoring quality assurance will not have positive affect on quality.
D) Quality inspection in Saudi Arabia cannot be important influencing the quality.

The data for the research has been collected through questionnaire via different departments, medium and small sized industries, probability sampling has been used. The correlation results show that there is a strong relation between quality and quality management showing that quality management is necessary for quality. It goes with quality assurance, quality, and quality-
Inspection, giving result that all these factors determine quality of the project.

The regression analysis based on the values from the questionnaire shows that if the values comes out to be negative that the hypothesis will be rejected, and for this research the values for hypothesis came out to be less than zero for each cases proving that the hypothesis were wrong and quality is affected by inspection, quality management and assurance. And this is the conclusion of the paper.

2.4 Quality Management System At Construction Project: A Questionnaire Survey By P.P. Mane, J.R. Patil [3]

The paper purposes to study the quality cost and time feature of construction project as he defines these as the dynamic modules to determine if the construction is going to be prosperous or not. The author suggests that, for quality management, quality planning, quality control and quality assurance needs to be kept in mind. According to the literature review by the author, the quality management is most vital in top level management as they are the ones who will control the quality for construction.

Lydia (2010) explains that for suitable quality management, it needs to be guaranteed that all, client, contractor and workforces are accustomed with quality management. As construction is manifold project involving many procedures side by side on a single project the roles of client, contractor and workforces are important. The research methodology of the project is a three step method

Step 1: Quality Planning

Step 2: Quality Control.

Step 3 : Quality Assurance.

And so this paper includes three types of questionnaire for each one of them. The conclusion of the research paper is that 80 % of the respondents believed that check list is and effective way of assuring quality, 60 5 preferences was given to fish bone diagram. 90 % respondents believed that quality of workman ship and 80% to site revise was main quality control On site.90% clams customer satisfaction ad main objective and 80% client satisfaction are the most important aspect of maintaining the quality.

2.5 Modeling Quality Management In Construction Projects - By F. Nasirzadeh, M. Khanzadi, A. Afshar, S. Howick [4]

The research paper focuses on presenting a dynamic mathematical system for modelling and simulating quality management process. The research integrates fuzzy logic and system dynamics simulation scheme. According to this paper quality means to meet legal aesthetic and functional

requirements of a project. This project deals with uncertainties with qualities and interactions between external risks and quality. The quality prediction system is used here to determine the values of two input parameters affecting quality failures. The simulation is carries out by keeping in mind, the internal aspects and external aspects that affect the quality. The quality prediction system aims to predict the values of the two factors

a) Probability of task being flawed
b) Probability that flaw is observed by implementing quality management.

The methodology is implied to a water project in order to assess applicability and performance and it was concluded that the uncertainties in the system were accounted for by integrating fuzzy logic with SD simulation. The failure of ongoing quality procedures can be determined and solutions can be assessed.

2.6 Construction Analysis Based On Total Quality Management And Six Sigma ethodologies By Qingyang Huang And M. Haseeb [5]

The paper focuses on analysis of TQM in accordance to organization strategy and its performance. This also highlights the quality problems and building quality, the paper states that the quality of project is affected by leader's contribution. The paper first describes quality assurance series as a series of processes.

a) Testing previous articles
b) Planning to improve
c) Designing to include improvements and requirements
d) Manufacturing with improvement
e) Reviewing
f) Testing

The six sigma process includes total quality management, strong customer focus, additional data analysis, project management and financial results. The six-sigma standards for a statistical data is a measurement standard that defines normal curve. The paper then discusses the results of previous research paper that describe six sigma technologies. The paper concludes that quality and its concepts are important factors for construction industry; it focuses on design of good facility.

2.7 Quality Control And Quality Assurance In Building Construction By R. Lakshmi [6]

The paper focusses on quality function deployment (Q.F.D) that is comparatively a new concept in construction industry as a tool to benefit the project managers. QFD is employed to improve quality and reduce cost of the project by ensuring that all construction related decision s are

driven by owners' needs.

2.8 Barriers And Benefits Of Quality Management In The Construction Industry: An Empirical Study By Peter Hoonakker, Pascale Carayon And Todd Loushine [7]

The author discusses the problem of defining quality in construction. The literature review consists of various studies defining quality in different aspects like Loushine et al (2006) in their work found definition of quality varying with researchers as 'meeting expectations of customer', 'reduced work and defects', 'conformance to I.S.O 9000 series', 'completion on time and within budget'. The author conducts interview to obtain information about quality, specifically quality performance measures followed by contractors, for this purpose 9 open-ended interview we conducted. These interviews were also addressed to determine company's efforts in quality management.

A questionnaire survey was prepared that conclude that measure of quality performance of contractor was his reputation in local market. The author then discusses the criteria for Malcom balridge award (award for quality management): leadership, human resources, customer focus, satisfaction, strategic planning, process management measurement and analysis business results. The study concludes that contractors see the importance of quality management as more number of clients approach them, the contractors who used TQM reported higher customer satisfaction, improved schedule performance, improved relationships and reduced work.

The paper also discusses the barriers to improve quality in construction industry.

The barriers to quality are

- Nature of work
- Large projects
- Labor intensive
- Seldom situated in same location
- Transient workforce
- Demand fluctuation
- Multiple contractors try to focus weather, occupational hazards, schedule delays, building defects.
- Multiple parties working together.
- Bidding process
- Changing culture in construction industry.

2.9 Construction Analysis Based On Total Quality Management And Six Sigma Methodologies Qingyang Huang And M. Haseeb [8]

This paper studies relation between total quality management and the organization strategies and its performance. It describes the definition of total quality management along with six sigma theory used as alternate to total quality management. According to Huang, quality is obtained from ideas of think tanks of management. Kaizen is a way of thinking

- Kaizen word has been used by Japanese to characterize a business strategy. This strategy involves the personnel working in organization together, to improve the quality without large capital investments.
- Kaizen is core principle of total quality management adding economic factors to quality.
- The principle of continuous improvement can and should be continually evaluated and improved in terms of time required resources used and resultant quality and aspects to relevant to the process.
- tools for determining quality.

The paper also describes quality assurance and the steps involved in quality assurance process as:

- Test of previous articles
- Plan to improve
- Design to improvements and requirements
- Manufacture or construction with improvements
- Review of new item and improvements
- Tet new item

The process of quality assurance is tedious and rigorous and Laos requires a lot of planning and testing.

ANALYSIS OF QUALITY CONTROL

All the quality related terms comes under quality assurance, as one need have quality assurance and then it will depend upon the person to follow different ways to implement check or perform quality measures, aka to assure quality. Quality control in earlier times was considered as prevention of defects, later statistical quality control was coined as quality control was a statistical process and consisted of the same methods.

Cost control

CF = CT/PT

CF= FORECAST TOTAL COST

CT= COST INCURRED TO TIME

CP= PROPORTION OF ACTIVITY COMPLETED AT TIME.

SIX SIGMA

tqm +strong customer focus +additional data analysis+ financial results+ project management.

SIX SIGMA is a measurement standard that defines a normal curve of statistical values or data provided; it represents the standard deviation, or variability within a given population around the mean. It follows a systematic procedure

DMAIC: Define measure, analyze, improve, and control. To follow this methodology, the organization should be well informed and control procedure must be established at every single stage. The paper concludes that construction plan development is directly related to development of good facility design, in order to maintain quality in construction every planner must weigh the cost and the reliability of different insuring technical feasibilities, and TQM principles are taken into account.

Table 1 : Six Sigma Description Table

Six sigma constriction strategies And Principles	Six sigma tools and techniques
Project Management	Statistical Constriction process control
Data Based decision making	Process capability analysis
Knowledge discovery	Measurement system analysis
Process control planning	Design of experiments
Data collection tools and techniques	Robust design
Variability reduction	Quality function deployment
Belt system (Master, Black, Green, Yellow)	Failure mode and effects analysis
DMAIC process	Regression analysis
Change Management tools	Analysis of means and variances Hypothesis testing Root cause analysis Process mapping

2.10 Cost Of Quality In The Construction Industry By Philip Barlow

The paper describes that the cost expended by construction companies as a result of poor construction quality are ignored by the companies, this is due to negligence of poor, management.

Quality here can be explained as a term that depends on person's perspective, i.e. it means different for different people, quality for construction can denote several things, according to Webster's dictionary quality can be classified into four definitions, out of which two refer to characteristics and two relate to a degree of excellence of goodness. From this it can be concluded that high quality goes hand in hand with material cost. The American society defines quality as "the totality of features and characteristics of a product or a service that bears on its ability to satisfy given needs". Higher quality leads to higher productivity, which leads to lower costs which results in competitive advantage.

According to Mc George and Palmer, quality has seven dimensions, construction performance, reliability, conformance, durability, serviceability, aesthetics, and perceived quality. As we know that quality is a vast and multiple-meaning term that can be applied in many different ways. The author also states that decisions made during designing phase inevitably have tremendous impact on the quality of project.

The cost of quality is broken down into four main categories.

1) Prevention – the cost incurred by contractor for the works, which are undertaken to stop or prevent internal or external nonconformance issues.
2) Appraisal - the cost incurred by the contractor in the process of conducting inspections, making evaluations and collecting data.
3) Internal failure – costs incurred upon the contractor due to providing unsatisfactory results before handling project to owner.
4) External failure- cost incurred upon the contractor when poor quality is discovered after handling project t owner.

The study concludes that if more expenditure is done in prevention then less expenditure is spent on failures.

2.11 Impact Of Quality Management In The Swedish Construction Process By Anne Landin

According to Landin. A quality the demand for quality assurance comes primarily from the central authorities via the client and quality systems shall be applied to the whole chain. The method followed was developing a questionnaire. This study concluded that quality management appears to be considered primarily as means of increasing effectiveness and enhancing competitive advantage. In addition, the outside demand from the customer can also be a reason for implementing quality management.

It was found that over the time degree of acceptance of ISO 9001 had been increased gradually. Landing. A also described quality as "totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs". Quality management contains both quality control and quality assurance along with quality policy, planning, improvement.

“If you keep your customer happy your business will prosper”, many construction units think that applying quality is expensive but it is not true, it is not quality that is expensive but rather non-conformance to it. The quality system requirements have been divided in to following

Table 2: requirements of quality system

Management responsibility	Quality system	Contract review	Design control	Document and data control	purchasing
Control of customer Supplied Product	Product identification and tracing	Process control	Inspection and testing	Control of inspection, measuring and testing equipment	Inspection and test status
Control of non-conforming Product	Corrective and preventive Action	Handling storage packing delivery	Control of quality records	Internal quality audits	Training
Servicing	Statistical techniques				

The ISO standard is process focused management technique. Where the process itself acts as transformation that adds value. However, some researches adds that implementing ISO adds to cost of process rather decreasing it. REEDY (1994) says “There are critics against ISO system claiming that ISO has potential to destroy the small companies if ISO is not implemented properly, the system with I.S.O works well only if the top management takes full responsibility for interpretation and implementation for the quality assurance program. In addition, ISO was not published as standard for controlling product quality.

Quality Audit

According to ISO 8402 quality audit can be defined as schematic and independent examination to determine If the planned arrangements comply with the quality activities followed. The objectives of quality audit are as follows:

1) Quality system optimization
2) Following organization planning
3) Monitoring procedure and effectiveness
4) To provide consistency
5) Analysis of effectiveness of standard design and specifications
6) To improve constructability of project documents
7) To determine training needs

Audit aims to provide comprehensive rather than day-to-day quality control; audit can provide vital assistance and information of quality management. By focusing on process the quality audit team naturally builds up TQM.

Quality management in construction process

Following the TQM process yields in better customer satisfaction, greater market, increased revenue and higher staff morale. The factors that evaluates quality are

1 reliability
2 assurance
3 empathy
4 tangibles

However, customer satisfaction is a key variable, many more variables can be deduced that affect the quality. The most common problems faced by specialized contractors are

1) Different customers want different quality plans
2) Customers often want to control the specialist contractor's quality plan
3) It is difficult for contractor to assure quality unless everyone has
4) The majority companies are small companies that cannot afford quality plans

The people who criticized ISO said that It was difficult to understand, It increased bureaucracy
It neglected economic matters like profitability

2.12 Implementing Total Quality Management On Construction Sites By Theo C. Haupt, Ph.D., M.Phil., Mciob, Mais; Daniel E. Whiteman,

The primary focus of TQM is involvement of every one, adopt new ideas, techniques, and suggestions that can be applied to improve quality of a construction project. For a company to improve, there has to be a change in mind set of top level management in terms of cultural and behavioral aspects. This paper aim to provide a basis framework, this seminar which titled "Safety Management towards Quality Construction" tries to delineate the relationship and the importance of these two areas. The concepts of safety management and quality management indeed are still new in Malaysia. A proposed model which is also a framework is seen as a procurable method on defining the basic concept of safety management meant to achieve the expected quality level. In the aspect of proposing safety application model, a directive method of the Total Quality Management is used. A basic management application model as suggested by Walker (1993), is proposed to be used as a generic model to highlight the key features. Findings from individual survey are used to delineate the key points or processes of the safety application model. Based on the findings of the study, the provided information indicates that unsatisfactory safety culture and lack of responsibility towards safety in general are what happened in the real construction field in Malaysia. There was inadequate imagination and ideas in propagating safety at work. Lack of management control leads to a lowering of performance standards; these standards may be training, communication, program, etc. According to management theory, management's functions are to plan, organize, command, coordinate and control, and all managers are expected to fulfil these functions.

CHAPTER 3
QUALITY IN CONSTRUCTION

3.1 What Is Quality?

Construction process can be very easily explained as a natural process, nature's processes goes in steps and in a very well defined manner. Take a river as an example; if the river flows within its banks, it is a source of nourishment to the valley, on the other hand if the river flows out of its banks it causes destruction, this simple natural phenomenon is sufficient to define construction. Say if construction is done with precautions taken (creating banks), it provides the population with usable resources, but if the precautions are not taken, the construction process can easily go out of hand and cause mishaps. The bank, if build with good quality material and good quality construction it can direct the river and keep it safe and usable, but if the banks are not of good quality it can lead to unwanted results, later it will require repairs more often and retrofitting, cost to compensate damages and worst case, loss of lives. Therefore, quality matters.

According to dictionary, quality is the standard of something as measured against other things of same kind: the degree of excellence of something. Further a distinctive attribute or characteristics possessed by something. The definition of quality varies with population, it can be in relation to the number of features in a project, it can be relative to just one function and its extent.

Kumar. A (2001) described quality as fulfillment of expectations. It can be defined as the ratio of the performance of contractor (project) to expectation of owner for the project. These statistics might be appearance, strength, efficiency diversity of project or any other criteria as specified by the owner.

$$\text{Quality} = \frac{\text{performance}}{\text{Expectation}}$$

The values of performance and expectation ranges on basis of ratings from 1-10, if the ratio is greater than 1 then it is said to be of good quality.

Various authors over period of time gave different definitions to quality for example Loushine et al (2006) in their work found definition of quality varying with researchers as 'meeting expectations of customer', 'reduced work and defects', 'conformance to I.S.O 9000 series', 'completion on time and within budget'.

- Design professionals believe that quality is calculated by the aesthetics of the building they design
- In building construction industry quality can be defined as fulfilling requirement by client, constructor, designer and regulatory agencies.
- In terms of function a project can be described as high quality project if the drawings are understandable, and terms like level of agreement of building, economics of construction, ease of operation and maintenance and energy efficiency are easy to describe.

According to studies quality is reduced reworks and defects, according to some authors it is conformance to ISO 9000, while for others quality is completion of work within time and budget.

As quality means different to different people, it has various methods and procedures for evaluation. Some people evaluate quality by aesthetics, by the amenities provided, by the strength, by maintenance, by service life, by amount of repair and retrofitting needed and many other methods, based upon these criteria of evaluating quality, long term and short term methods can be derived. the methods shall be discussed later on in this study. The quality can be calculated by various methods after completion of a project, but what are the methods to imply quality to a project, it is not as easy to provide a good quality work or service just by a single step, it includes a really simple but elaborate method to adhere to quality. Starting from planning to provide quality to a work, then paying attention whether quality controls are being followed and finally determining what are the final quality outcomes. This all is done by a simple process “steps”. The steps are explained in detail in the section 1.3 “how to implement quality”.

As needs are ever changing and conditions are too, the quality of a structure can be upgraded too, it can be post construction upgradation or upgradation during construction process itself or during process of repair and retro fitting. Quality management itself is a process of managing quality of structure in every possible way and keeping it updated with time and modern needs.

3.2 Importance Of Quality

To answer the questions of "why do we need quality", just an understanding of "need" is enough.

As stated earlier quality means different things to different people, or in other words quality is not itself a standard, it is a standard of living. Needs define the quality a person is expecting, for example in areas with hot climate the client will need a project with good QUALITY thermal isolation. Also for a client building nuclear power station, the needs would be particularly of strong structure with minimal permeability and high resistance to radiations, or good quality nuclear structure.

As the needs differ, the standards differ, and as the standards differ the procedures differ, eventually at last we come down to owners will. The owners decide what kind of quality they need; it is contractor's duty to provide the decided quality.

In some researches it has been found that people opting for quality control and planning or total quality management have paid more initially or during the construction phases as compared to clients who neglect quality management. As, implementing quality needs resources and work force , but in the long run, the costs of maintenance, repair retrofitting and defect correction, the clients who neglected quality management have to undergo large capital investments to keep the project in working stage. It can also be said that the cost of quality is very less as compared to cost of neglecting quality management. This being another reason to opt for quality management, many other reasons follow like:

1) Quality construction provides safety.
2) Increasing demand for better living standards
3) Economic benefits.
4) Quality in construction increases the life of structure
5) Quality management directly affects the strength and serviceability of structure
6) Quality implementation proves to be a good skill in construction industry
7) Quality management keeps a check on the errors of construction.

The quality of construction is linked with quality management in all the phases of the life cycle of the project where design and construction are the two main phases of the process that determine the overall quality of the project. As the clients are moving towards more safe and high performance era, the quality of construction needs to be up to date as well.

3.3 The Flow Chart Of Quality

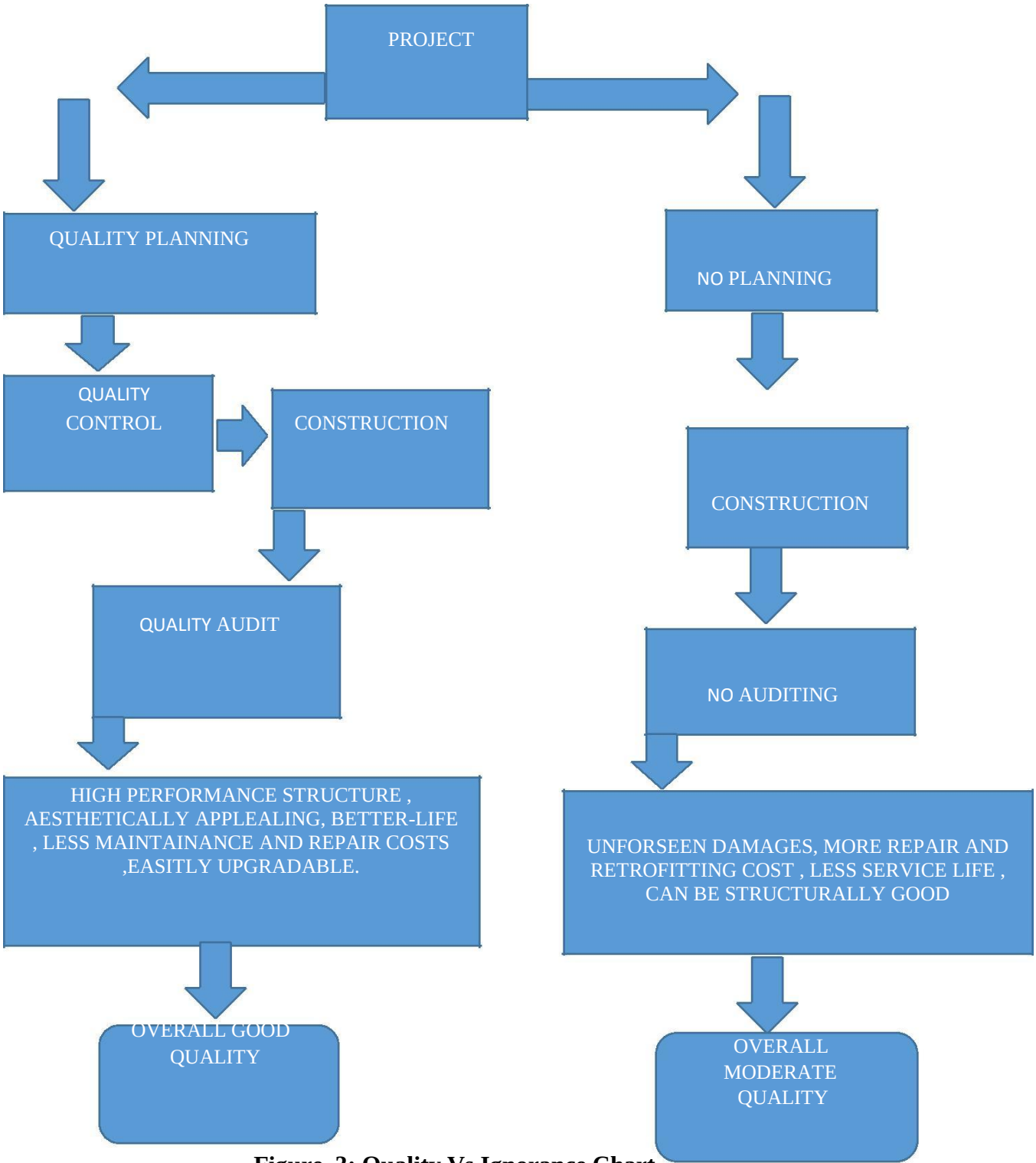


Figure 3: Quality Vs Ignorance Chart

3.4 How To Implement Quality

Quality of finished product can be attained by providing quality in procedure and to every component of construction but still there are factors that decide the quality procedure and quality system, this study will define some of the possible variables and their effects on quality.

The procedure to follow quality is defined by a quality plan, the plan defines the structure to take precautions and correct methods of construction, further quality assurance is done to check it the quality control has been done correctly during the construction and finally quality auditing is done to document all the steps and procedures done in the specific work, this documentation is important for future upgradation and evaluations. The quality planning, quality control and quality auditing will be discussed later in the study. By following the above mentioned procedures, the contractor can assure total quality management to the work.

To attain speed, accuracy, safety and good quality of work, all the procedures in the project should be scheduled and preplanned, because without planning for the work, scheduling and accounting for contingencies the project can be affected drastically by a small problem, and so planning is a variable that affects the quality of work directly. These planned procedures are to done in steps, i.e. the work is divided in to smaller groups and then is being focused on, also known as work breakdown structure. This structure helps in efficiently completing the job with maximum output and step by step approach keeps the quality of the work in focus. But, before that, it is necessary to give an introduction to steps to follow for providing quality to a project.

3.4.1 Steps

From various literatures it can be easily deducted that quality comes in steps, meaning, to attain good quality finished word, the worker needs to provide good quality to every step of the work, starting from planning to collections and selection of raw material to construction process and finishing. A slight ignorance to quality can lead to bad quality of work eventually, so it is necessary to provide quality to every step of process.

By providing quality it is meant

1) that the process is done according to a specified way/procedure and not just by know-how.
2) That the material (if included) is selected based upon requirements of owner.
3) The material is selected based upon its characteristics of strength, aesthetics, procedure of construction.
4) The workers employed are educated well enough (either by experience or by knowledge) to select material, provide good workman ship and tackle any contingencies if any.
5) That the safety of workers and structure is kept in mind and is actually followed.

The first step towards providing quality to project is planning for quality.

A. Quality Planning

The first step is quality planning, its main objective is to determine which quality standards are required for the project and how to satisfy the quality standards needed for the same.

A list of requirements is made and then subsequently the practices are listed to attain proper methodology for the work. Quality planning is a process of listing the steps and procedures the attain the expected or the threshold of quality. Planning includes quality control, assurance and management steps. A well defined plan has to be introduced so as to define the stages of working ,inspecting and upgradation.

B. Quality Control

Monitoring specific project procedures to determine if they comply with the relevant quality standards and identifying ways to eliminate the causes for unsatisfactory results and performances, the contract documents consists of clear, accurate and complete description of the facilities to be considered that conveys the intent of the owner regarding the characteristics of the type of work needed. Quality control in construction typically involves ensuring compliance with minimum standards of material and workmanship in order to ensure the performance of the facility according to the design. These minimum standards are contained in the specifications. QC activities should encompass all the phases of the project including design and construction.The process for quality control is:

1) Determining program of process quality control.
   a) Quality of technology
   b) Measures for input material.
2) Controlling quality of conditions: control measures for human, material, equipment, method, machine.
3) Inspecting quality of effectiveness of process activities
   a) Self-inspection
   b) Mutual inspection, when contractor and client both inspect the work by workers.
   c) Handover inspection, when the inspection is carried out by a third party.

One of the simplest way of providing quality and controlling it is the P.D.C.A cycle.

The P.D.C.A cycle stands for PLAN. DO. CHECK. ACT. According to this procedure, before starting a work planning is done to determine the checks and milestones for the work.

DO: according to the plans, the work is carried out, i.e. the work is done.

CHECK: the work is then inspected for any errors or defects, if there are no errors then the cycle goes on to a different work, but if errors exists the next step i.e. ACT is carried out.

ACT: upon encounter with any error the action is taken as to isolate the error from the works and then apply the P.D.C.A cycle on the error.

C. Quality Assurance

Evaluating overall project perform on a regular basis to provide confidence that the project will satisfy the relevant quality standards. Quality assurance is the planned and systematic activities implemented within quality system and demonstrated, as needed, to provide adequate confidence that an entity will fulfil requirements for quality. Quality assurance is the planned and systematic preventive activities which increases productivity by placing the emphasis on product and service (Oakland, 1995). As noted by Dale et al, (1994) quality assurance emphasizes on defect prevention and focuses on the prevention of the production of non- conforming products in order to provide the confidence of organizational outputs and ensures meeting customer satisfaction. Moreover, it is aimed to control quality at all stages of production that are designed to ensure that the final product and service meets customer expectations. Quality assurance proved that quality is created in the design stage, but not in control stage because all the activities are done before manufacturing or planning process of a product or service respectively. Thus, it involves the development of new operating approaches that avoid or reduce the chances of defects in a product or service.

According to Frank & Ronald (2013), quality assurance requires systematic preventive activities to ensure final products or services due to designing of the business process of production meet customer expectation. Thus, quality assurance is done by set of activities before the manufacturing process of product and service in order to control quality at the all stage of production. It is necessary to provide confidence of organization outputs to maintain close link with customers. Therefore, customer needs and expectations determine by better design and development of new products. Quality assurance for product and service associated the planning process to avoid and reduce the cause of defects in the first place. Moreover, it can be made by all actions and programs with deep involvement of product development to assure quality improvement. As reported by Joachim (1993) quality assurance is concerned with continues improvement in all the process of production from level of planning and preventive activities to the execution of work. Focus on quality assurance will lead fulfill customer expectation and satisfaction that is determined by design, distribution and development within detailed process. The principle behind the idea of quality assurance is basically the idea that defects can be prevented. Thus, it refers to the improvement of organizational output to increase customer value. Product operating in dynamic environment is able to carry up set of activities in quality assurance due to result of changes in customer needs.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 Introduction

The research methodology of this study involves collection of data via means of literature review and mainly interaction with the workers with help of interviews and questionnaire. The questionnaire has been designed according to the variables found during the literature review and data collection by means of past studies in the same field. To determine the effect of variables on quality , we will first have to find out the variables. After finding out the variables, the variables can be categorized into nomenclature. The critical factors then can be projected to analysis using mathematical tools and software. This analysis then will be helpful in selecting the contractor, the reasons responsible for bad quality work, and improvement needed.
The first step is to find out the variables and from the literature review there are a couple of variables that are dominant in this study.

4.2 Variables

Anything that affects quality of construction directly or indirectly is a variable of quality. Variables are the conditions, methods, principles, or any other entity that upon execution can either increase the quality of a project or decrease the quality of the project. To provide the project with adequate quality , it is necessary to keep in mind that small things can have a drastic change in the quality, a negligence in the selection of size of screws with just a couple of millimeters can put the whole structural component at state of risk. The variables may not seem of much importance to a contractor but the multinational companies keeps these variables in mind as soon as the news of a new tender passes, and this is one of the major cause for either rise or fall of an industry.

In this chapter, some of the variables are identified based upon the studies of success of qualities and failures too, these variables or factors are then classified into four categories. From the literature review the variables that were highlighted in the previous studies are as listed below, further these variables are categorized and listed.

4.2.1 Managemental Variables

The factors which affect the quality of construction and are related to the top working unit, or the management are called managemental variables. The work of the top management is most of the written work, guidance, inspection and provide it to the lower working classes to execute, if the quality works are not defined, they can't be executed by the contractors and workers, say if there is any kind of error and the quality plan has been compromised, the laborers would have no idea about the quality plans and they would be helpless in cases of emergencies and disasters, as their work is to do just what has been told. Similarly, if the contractor has no idea of quality plan itself, the workers will not be able to execute the procedure. Any work would include a manager may it be a foreman or a C.E.O of a company provided the scale and potential of the working body. Where ever there is a management involved there are the variables that will affect the Quality of the work. Many studies claim that the managers are responsible solely for the defects in quality. However, it can not be assured that only managers or the management is responsible for the defects and negligence in quality. Quality assurance and control is a teamwork and so is the negligence experienced in the same process.

Some of the managemental variables identified from literature review are as follows.

1. Assurance
2. Audits
3. Benchmarking
4. Certification Cost
5. Clearly Defined Measurable Goals
6. Commitment
7. Communication
8. Contract Review
9. Control
10. Corporate Quality Culture
11. Cost Reduction
12. Customer
13. Degree Of Innovation
14. Employee Empowerment
15. Experience
16. Commitment
17. Communication
18. Contract Review
19. Control
20. Corporate Quality Culture
21. Cost Reduction
22. Customer
23. Degree Of Innovation
24. Employee Empowerment
25. Experience
26. Finance
27. Handbooks
28. Inspection
29. Is Standards
30. Organizational Culture

31. Planning
32. Prequalification Of Contractor
33. Profitability Of Company
34. Quality Data And Reporting
35. Shared Vision Towards Quality
36. Size Of Organization
37. Statistical Process Control
38. Strategic Quality Management
39. Top Management Commitment
40. Type Of Industry

4.2.2 Contractor Variables

The activities, and entities that a contractor either follows or ignores during the project and eventually affects his work are the contractor variables. Mostly for the rural areas the contractor is the head of construction, unlike large companies, there is no specific personnel appointed for quality assurance and control. It is duty of contractor to appoint best work force, to buy best and economic equipment for his workers, to review the contract for the clauses and many more. The contractor will have to manage all the work by himself and so his expertise and experience in the field determines the standard of quality he can provide. Some of the variables that a contractor's job encounter are as follows:

1. Climate
2. Commitment
3. Communication
4. Competition
5. Continuous Improvement
6. Contract Review
7. Control
8. Corrective And Preventive Action
9. Customer
10. Customer Rating
11. Degree Of Innovation
12. Education And Training
13. Employee Empowerment
14. Feedback
15. Finance
16. Finance
17. Heterogeneity Of Services
18. Inspection
19. Inspection Product /Service Design
20. Leadership
21. Methodologies
22. Planning
23. Prequalification Of Contractor
24. Process Management
25. Product Service Design
26. Profitability Of Contractor
27. Quality Data And Reporting
28. Resources
29. Serviceness
30. Size of organization
31. Strategic quality management
32. Team work
33. Top management commitment
34. Type of ownership
35. Experience
36. Transport

4.2.3 Material Variables

Material variables can be defined as the properties and characteristics of the construction material that affects the quality, cost, production, life are the commonly known characteristics that we use to define the quality of material. It is known that the quality of material used in the construction process determines the quality of the finished product. A good quality material with excellent workforce will lead to an outstanding project, but with bad quality material and any kind of workforce the quality is said to be compromised to an extent. And so it is necessary to define these variables.

Some of the material variables are as follows.

1. Continuous Improvement
2. Control Of Non-Conforming Product
3. Finance
4. Life Of Material
5. Operating Procedures
6. Planning
7. Product Design
8. Purchasing
9. Resources
10. Storage And Handling Of Products
11. Shelf And Service Life
12. Supplier Management
13. Tangibles
14. Type Of Material
15. Weather
16. Working Methodologies
17. Cost
18. Inspection
19. Profitability
20. Delivery Of Material.
21. Transport

4.2.4 Workforce Variables

As the workforce or the labor unit is in the most basic of construction process, the entities that affects the working, efficiency, accuracy of the workers are called workforce variables. It is clear that without the labour unit no construction project can be completed and the quality of the project is in hands of these forces, the management unit may apply policies, the contractor may provide good equipment and materials but it is in hands of the workers that quality of work be it in any sense, is achieved. Needless to say, laborers in rural areas are not well educated but the level of quality does not just depend on education, it depends upon the leaders of the workforce, the communication, dedication of both the leader and worker are the most basic variables that affects quality.

Some of the variables are listed below:

1. Communication
2. Construction Methodologies
3. Continuous Improvement
4. Control
5. Education And Training
6. Efficiency
7. Empathy
8. Employee Empowerment
9. Finance
10. Heterogeneity Of Services
11. Implementation
12. Inspection
13. Planning
14. Process Management
15. Team Work
16. Weather
17. Workforce
18. Cost Of Workforce
19. Experience
20. Safety Precautions
21. Transport

4.2.5 Critical Factors

The variables found from the literature review and the interviews are really large in number. And thus cannot be used for he analysis purposes, so for the ease of the analysis these variables that are already classified into categories needs to be listed according to importance and the frequency with which they are observed. Critical factor can be defined as the factor that is present in all the four classification (managemental, contractor, material and in workforce variables). These are naturally critical as the are ever present in the four categories and based upon these critical variables it is easier to define a hypothesis that the variable are inter related or not.

It is assumed, based on the researches by alternate authors that the variables are interrelated but the relation is not well defined and to define the relation it is important to state the hypothesis. So, as the variables are inter related, it can be concluded that the critical variables efficiently represent the whole category.

4.3 Factors

The critical factors observed from the literature review are considered according to their occurrence. The factors observed are not all critical so the factors that repeat and reappear in the list are considered and given rating. The rating describes the number of times "variable" occurs. For example, if *cost* occurs in all the four classifications it is written as cost 4

However, if cost occurs in just 3 of the four classification, it shall be written as cost 3, with 3 defining the number of times cost has been observed in the list of variables in the classification. The observed factors are listed below and adjacent to factors it the occurrence of the factors.

Critical factors

Table 3: Critical Factor Occurrence Table

Serial number	Factor	occurrence
1	Control	4
2	Commitment	2
3	Communication	3
4	Cost	3
5	Customer	2
6	Degree of innovation	2
7	Employee focus	3
8	Experience	3
9	Inspection	4
10	Planning	3
11	Prequalification	2

As it is clear that the most important factors for quality in construction is control and inspection. The meaning of the two most important factors is that in every classification of material management workforce and contractor control in process and the material is of utmost importance to initiate quality work and provide quality.

The rest critical variables states the obvious i.e. by considering critical variables stated in the table, quality can be initiated in the process and in the material. However the study does not, in any situation states that the other variables found are not necessary, t is stated that these critical variables are related the variables in the same category but are of certain more importance.

Further these variables are to be used for designing the questionnaire for the analytical purposes. As the analysis is to be done using software and the software only understand the numeric as the inputs, the question designed will be designed to score the critical variables.

4.3) InterC.E.P.T.

InterC.E.P.T can be defined as the interrelation between COST, EXPERIENCE, PLANNING and TIME. The logic behind InterC.E.P.T is that the variables observed during the critical table are all linked either directly or indirectly to these factors. And also COST, EXPERIENCE, PLANNING and TIME are also interrelated to each other, this leads to a hypothesis

- Are the critical variables related to each other?
- Does quality really depends upon these stated variables?
- What is the intensity and the degree to which these variables affect quality?

4.4.1 COST

It has been observed that cost has a direct relation with quality in construction, to be more specific it is an old tradition of getting high level of quality assurance with high capital investment. Never the less, cost can be directly linked to quality, and indirectly. If the contractor is to put more money on workforce rather than quality inspector, he might save money but quality would be hindered. The cost plays a vital role in the construction process, as it is the base of the scale and quality expectations. Cost has to be considered while planning the project and deciding the products to be used. Cost is important for deciding the location.

Cost invested by a owners will lead to degree of experience of the worker and contractor, and will affect he planning. Planning is directly affected with cost in two ways

a) a good planner will invest maximum resources in minimum cost bracket and hence improve the economy of the project without affecting the quality but will have a higher fee.
b) Without hiring a planner it is still possible to get best quality work by acquiring good quality products and skilled labour but the cost bracket will be large and it may hamper the profit without affecting the quality desired.

Cost implied on construction is of various types such as :

- Investment by a third party
- Material cost
- Labour cost
- Equipment cost
- Transportation cost
- Maintenance cost
- Safety and inspection costs
- Miscellaneous costs

4.4.2 EXPERIENCE

it cannot be said that more the experience more will be the level of quality because, the working procedure in previous sector may be of different profile. - an experienced person, may he be owner, contractor or worker can easily decide the quality of the project, experienced personal may not even need special construction planner for rural area works as he will know the work details, limits, expenses, and contingencies. Experience can reduce cost , propose good plans, and reduce time To list the reasons that explains why experience is related to quality in construction a few points are explained below.

- The old job may be of different profile.
- The current job may be unsupervised.
- The working procedure might be correct or wrong, and that explains experience has a strong effect both directly and indirectly on quality od construction.
- The job may be one of a kind and might there be workforce with no or negligible experience.
- The experience in any field of construction is related to the other as construction goes with simultaneous procedures at an instant.
- With ample experience it is easy to cut cost and improve quality.
- Experienced worker will be able to plan, execute and control the procedure very effectively.
- Experienced workman can be additional asset to company as he can provide necessary knowledge and know-how of the procedures and machines.

There are numerous other reasons that supports experience being in *interC.E.P.T* .

4.4.3 PLANNING

Planning is another important aspect for quality in construction, perhaps one of the most important ones. Planning can effectively save cost, time, material. With planning almost any scale of the work can be done in any given circumstances, under any possible working capital investment, without affecting the standard of quality. Planning takes very less time and almost no or negligible capital investment but on contrary it improves the quality of construction in every possible stage, making the project up to quality standards and safety standards. Planning is needed in construction work, a new worker might work without experience and planning but a basic know how is also planning. For example a new worker or a contractor will know to supply material and then start the work, he can not possibly go wrong with this process and planning. Work cannot be started without the material and so planning is observed, it is pure logic and basic instinct. Also the work can be assigned maximum number of workforce to complete the work before time but the cost will increase, so there will be a very less chance of getting the work done in optimal end conditions

But a good planner will distribute the material ,time and work force accordingly and will eventually complete the project in time and within the cost bracket, with maximum utilization of work force, or in other words with optimal end conditions.

Some of the salient features of planning that makes it critical are:

- Planning quality and adhering to the plan is the best and most effective way to provide and assure quality in construction.
- Planning reduces time of construction.
- All the big projects and multinational projects require planning.
- Quality planning is closely related to project planning.
- Planning is an effective way to cope with uncertainties and contingencies that hinder the quality of construction.
- Planning improves problem handling and securing resources to meet quality expectations .

4.4.4 TIME

Time, both directly and indirectly affects quality in construction. More time leads to good planning, good paced work and satisfactory inspection and also corrective efforts. More time also means that the cost can be handled accordingly, meanwhile less time means fast pace work and more possibility of errors. Time then affects the other critical variables; more time means less cost to be implied on machine centered work. Less time would mean more effort on capital investment, greater deal of experience and expertise required and fast-paced work required more planning. the fourth element, is also related to the other elements as , time determines the resource exploitations, more time limit will ease the planning , inspection, and cost , a tight time window will require good planning capabilities. Inspection and suggestions for improvement required time for corrective measure and so if influences quality in long run.

CHAPTER 5.

DESIGN OF QUESTIONNAIRE

5.1 INTRODUCTION

The second step in this research is to design a questionnaire keeping in view the variables that have been discovered from the literature and the interviews. The questionnaire consists of multiple types of the questions like:

- Open ended questions to find out the direct and straight forward replies.
- Yes or no questions that limits the responses to two basic binary values and thus can be used in the analysis as the analysis can only be done in terms or numeric.
- Rating questions to determine the importance given by the respondents to the questions.
- Selective option question to chose form only one from the multiple options available.

The different types of questions helps in determining the scale and magnitude of the responses allocated to each of the C.E.P.T. variables. The designing of questionnaire has been done to find out the top variables from the list discussed above and perform analysis on these variables. The aim of the questionnaire is to convert the statement into numerical values as these numerical values are necessary for the analysis of the variables. The conversion of the statements to numerical values shall be discussed in detail in later study.

- OPEN ENDED : The question “have you expelled any worker?” is an open ended question here and its aim is to find whether the employee is strict with the workforce or not. Also in context to if he has fired any worker due to irresponsiveness or lack of skill or any negligence amongst many other reasons. These qualities direct towards the different variables that affect the overall quality. Mainly planning and experience. The reason behind this question is, an experienced contractor will keep in mind the cost and planning required for keeping an unfit worker, considering the effect on the time , cost , quality, progress. The open ended question is subjective to find out type of personality of the respondent.
- YES/ NO : The yes /no type question limits the question, as it vanishes the excuses or the reasonability. Moreover this type of question is critically useful for analysis as the values can be changed from a string (statement) to numeric value. However, yes/o type question does not give a level or intensity of how the variable affects the question. For example “do you provide safety ?” this question clarifies, whether the respondent provided or does not provides the safety feature but it does not clearly specify to what level the safety is provided according to the job. Also known as the FUZZY PRINCIPLE. This will be discussed later in the study.
- RATING : The rating type question helps in study by telling us about the details or the level of the response, for example describing the work.

The questionnaire is designed based upon the pre-described factors and the question type discussed earlier.

5.2 SURVEY FOR QUALITY

NAME: AGE:

OCCUPATION:
SPECIALISATION:

Q1) What is duration of your experience in this field of work?

A) 0-5 Years
B) 5-10 years
(c) 10-20 years
(d) More than 20 years

Q2) Have you worked with any other superior?

(a) Yes specify duration (b) no

Q3) What is your annual profit? (approx.) :

Q4) Does your work depend on climate?

(a) yes (b) no (c) maybe

Q5) How many workers work currently under you?

(a)0-5 (b)5-10 (c) 10-20 (d) more than 20

Q6) How would you describe your work? Provide rating.

(a) Quality 1 2 3 4 5
(b) Cost 1 2 3 4 5
(c) Time 1 2 3 4 5

Q7) What quality of product do you use?

(a) According to customer
(b) According to quality
(c) According to cost
(d) According to circumstances

Q8) What services can you provide to customer? (list)

Q9) How often do you consider your worker in decision making?

(a) never (b) sometimes (c) fairly (d) frequently (e) always

Q10) How often workers report you problems related to

(1) **MATERIAL** (a) never (b) rarely (c) sometimes (d) frequently (e) always

(2) **PROCEDURE** (a) never (b) rarely (c) sometimes (d) frequently (e) always

Q11) How would you rate your workers, (on a scale of 1 -5, 1= poor, 5= excellent)

(a) Attendance	1	2	3	4	5
(b) Health checkup	1	2	3	4	5
(c) Education	1	2	3	4	5

Q12) Have you expelled any worker? If yes, then why?

Q13) What are your daily working hours?

(a) Fixed 8 hours
(b) Fixed 10 hours
(c) Fluctuating
(d) Fluctuating with overtime

Q14) What would you prefer? please rate according to preference from the two quality, time and cost options

(a) Quality over time. (c) time over cost (e) cost over quality
(b) Quality over cost (d) time over quality (f) cost over time

Q15) Do you get suggestions for your work from customers? how many for last project?

(a) 0 (c) 5 -10
(b) More than 10 (d) doesn't involve customer

Q16) Have you introduced new practices to work?

(a) 0 -3 (c) 3-6
(b) More than 6 (d) can't remember

Q17) How often do you inspect your workers?

(a) Very often (b) often (c) sometimes (d) when needed (e)never

Q18) For a new job of medium scale, how much of following would you need? (approx.)

(a) Men
(b) Cost of material
(c) Time

Q19) Do you provide safety equipment to your workers?

(a) Yes (list) (b)no

Q20) Please give importance (0-5) to following factors stated in the table related to quality . (tick mark)

factors	0	1	2	3	4	5
Type of project						
Safety						
inspection						
Communication						
Customer						
Experience						
Innovation						
transport						
Training						
Team work						
Leadership						
Competition in market						
location						
Weather						
cost						
Planning						

Table 4 . Questionnaire table

CHAPTER 6
RESULTS OF QUESTIONNAIRE SURVEY

6.1 INTRODUCTION

For the analysis of the variable, it is necessary to deduce the many variables in to questions and then to deduce the solutions to the questions into numeric values that will give us concrete readings to carry out hypothesis and analysis. For the purpose of analysis, the questionnaire was sent to a group of working class citizen including foreman, carpenter, mason, electrician, contractor, junior engineer and many others. The details of respondents is listed later in the study.

Every question represents some or the other quality from the four critical variables. And the results will then be helpful in analyzing and finding out co relations, effects , and relations along with importance in the further studies.

6.2 CALCULATIONS

6.2.1 SCORING

The scoring of the questionnaire has been done to account for the critical factors of COST, EXPERIENCE, PLANNING, TIME.

Each question has been assigned a variable relating to which the response shows the numeric value. This numeric value is then added to the C, E, P, T. table and then the total score per variable is calculated to give a percent value.

An example of this process is described below.

Q1) What is duration of your experience in this field of work?

A) 0-5 Years
B) 5-10 years
(c) 10-20 years
(d) More than 20 years

the scoring values are as follows corresponding to each response :

Q1) What is duration of your experience in this field of work?

A) 0-5 Years (**E2**)
B) 5-10 years (**E6**)
(c) 10-20 years (**E4**)
(d) More than 20 years (**E8**)

The E***x*** describes that the response is given a score corresponding to experience and value assigned is 2,4,6,8 respectively, keeping a factor that no worker is totally new to the work and will know the basic know how in a couple of hours, so the minimum value assigned is 2. The maximum limiting value is 8 and it is maximum value that can be given to any variable. The values assigned shows the importance being given to the variable. In some cases when the variable is not related to question or to the situation in which the question is asked then the variable is assigned 0 value.

In the case with multiple values similar approach towards importance has been followed but as it is clear that all t he variables cannot be given equal importance the values are inter-related, to clealy explain this situation let us consider a question form the survey.

Q7) What Quality of product do you use?

(a) According to customer
(b) According to Quality
(c) According to Cost
(d) According to circumstances

In this question a logical relation between the variables has been created to not only to relate the variables but also to consider the difference in the importance that has been created for the other variable. Without defining a relation all of the questions of survey will get maximum values for a particular

variable and minimum for the related one, furthermore it also compensates the score to a realistic value, i.e the end score will be effected to decimal places due to a slight change in answering pattern.
The relation between the variables is provided to assure maximum authenticity of the answers. For example the person can put cost as the most important factor in some question and meanwhile he might keep planning as top priority this will lead to a similar and monotonous result when every person will give all the facors equal priorities and hence the result would be fake. The principle of relating is to say that if a factor is given importance the other factors may be given equal importance or a bit little less importance.

6.3 Scoring Table

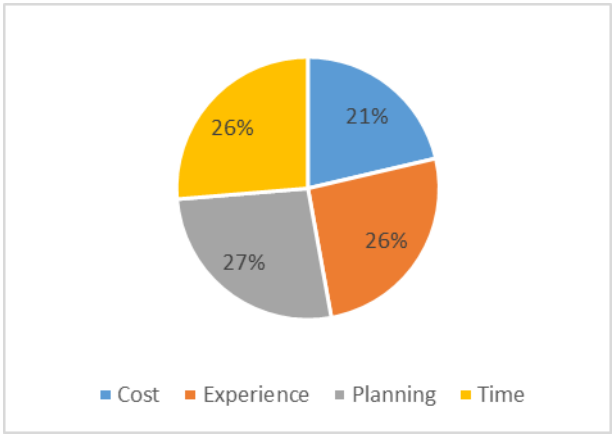
NAME	RAKESH
Specialization	engineer
Age	22

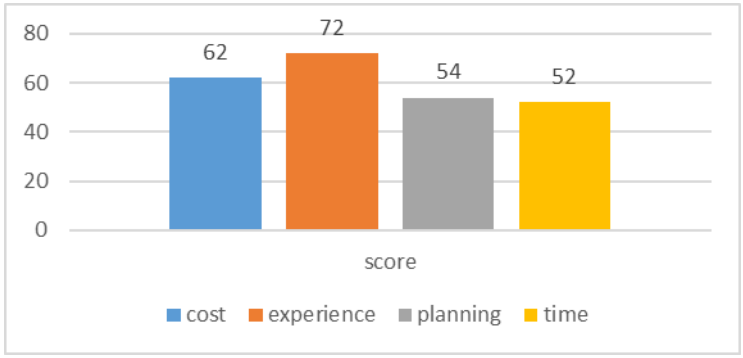
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	2	8	4
ii	8	4	8	2
iii	8	4	4	4
iv	4	4	8	4
v	2	8	6	4
vi	2	8	6	6
vii	6	2	8	4
viii	2	4	2	6
ix	4	6	4	6
x	4	6		6
xi	6	6		6
xii	2	6		
xiii	0	6		
xiv	6	6		

TOTAL	62	72	54	52
SCORE	62	75	77.1428571	76.4705882

DELTA 71.8562874

Table 5: Scoring Sample





The scoring is cumulative. As the number of questions designed for every variable is different in number, the score obtained for a particular variable needs to be divided by the maximum value of the variable , i.e adding all the maximum values of the responses for the variable.
The delta values is the ratio of the marks obtained to the maximum marks of the questionnaire, considering all the variables, which in this case is 334.

The delta value is of great importance. It not a score that can compare the various respondents but a value that is used to group the people of same factor mentality, further more it can be used to find the trends. The maximum value that delta can obtain is 97 and the minimum of 23, there is no bad or good delta value as the delta value does not describes the quality implementation but it describes the combination of the factors that the respondent thinks are most important for the quality implementation.

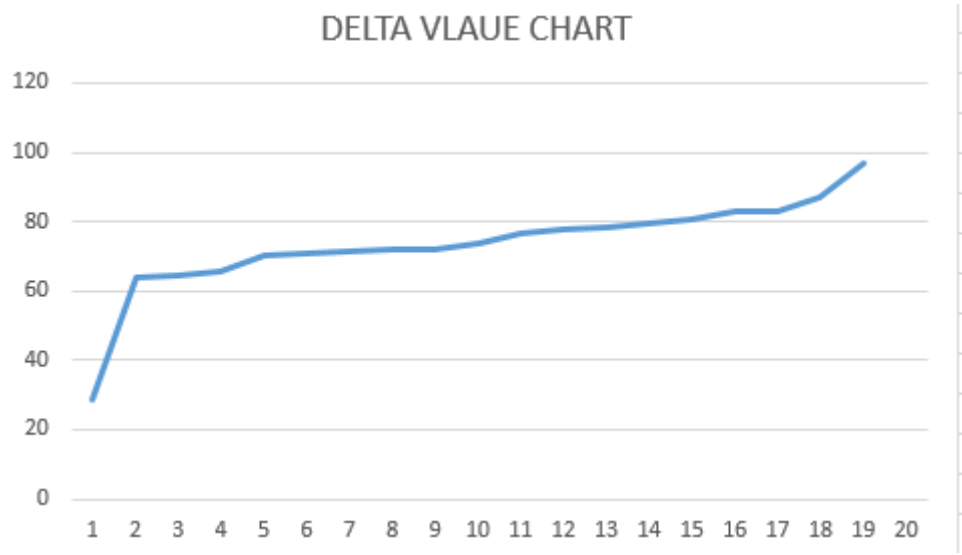


Figure 5: Delta value chart

6.4 Delta value

The delta value was obtained by dividing the total score obtained by the respondent against the maximum marks of the questionnaire. The delta value can be used to categorize the respondent into classes that lays emphasis on the specific value of the interCEPT.
From the feedback of the survey it can be concluded that:

- The respondents who considered time as the most important variable had the delta value ranging in between 65- 75, with a slight of exceptions. The number of people who gave time as maximum priority was 4 respondents out of 16 . This suggests that the people who prioritize time against planning and cost also have low experience.
- The respondents who gave cost as the maximum priority had delta value ranging from 70-73 and also showed significant values of experience. This states that the experience workers keeps cost in mind to obtain maximum profit, also these people gave time as least importance.
- The respondents who gave planning as the maximum priority had the delta values between 70-80.
- The respondents who gave experience as the maximum priority had the delta values ranging from 70- 75.

6.5 ANOVA

ANOVA stands for analysis of variables, it is the first step regarding the analysis is to test whether the variables are really conforming to the quality or not. This in statics is referred to as "testing the hypothesis". The testing of hypothesis is the first step for the accompanying procedures. If the hypothesis states that the variables are not related to quality and according to ANOVA the hypothesis is liable to, be "failed to be rejected" it would mean that the variables are related to quality. In this case the study is bound to move further, otherwise the study would show that the variables are not related and the study would be a futile attempt to prove the null hypothesis.

6.5.1 Hypotheses of ANOVA

These are always the same.
H0: The (population) means of all groups under consideration are equal.
Ha: The (pop.) means are not all equal. (Note: This is different than saying "they are all unequal "!)

In this study the hypothesis is considered regarding the relation between the variable and the quality, so, the hypothesis will state that
H0: (null hypothesis): variables are related to the quality in direct or indirect fashion.
H1 : the variables are related to the quality.
ANOVA works by finding the variance in between the groups and finding out the variance within the groups. Variance *"in between "* means that the variance in the values of factors considered in the study. For example considering factors of *interC.E.P.T ,* the variance in responses between cost and planning and time and experience. Variance "*within*" means ,the variance observed in the responses for any one of the four factors. Like the scoring provided by the respondents for cost alone and so on.

6.5.2 Assumptions of ANOVA

Similar to many other of inference procedures, ANOVA has some underlying assumptions, which should be in place in order to make the results of calculations completely trustworthy. They are as follows:

(i) The Subjects are chosen by means of simple random sample.
(ii) Within each group, the response variable is distribute normally.
(iii) While the population means shall be different amongst the groups, the standard deviation for the population is the same for all groups. Fortunately, ANOVA is somewhat robust (i.e., results remain trustworthy despite mild violations of these assumptions).
Assumptions (ii) and (iii) are close enough to being true if, after gathering SRS samples from each group, you:
(ii) Look at normal quantile plots for each group and, in each case, see that the data points fall close to a line.
(iii) compute the standard deviations for each group sample, and see that the ratio of the largest to the smallest group sample s.d. is no more than two.

6.5.3 Calculations for ANOVA

If the variability between groups/treatments is large relative to the variability within groups/treatments, then the data suggest that the means of the populations from which the data were drawn are significantly different. That is, in fact, how the F statistic is computed: it is a measure of the variability between treatments divided by a measure of the variability within treatments. If F is large, the variability between treatments is large relative to the variation within treatments, and we reject the null hypothesis of equal means. If F is small, the variability between treatments is small relative to the variation within treatments, and we do not reject the null hypothesis of equal means. (In this case, the sample data is consistent with the hypothesis that population means are equal between groups.)

6.6 ANOVA CALCULATIONS

SAMPLE 1	X- Mean	$(x \text{ mean})^2$
COST		
26.00	0.93	0.87
27.00	1.93	3.74
26.00	0.93	0.87
26.00	0.93	0.87
25.00	-0.07	0.00
22.00	-3.07	9.40
28.00	2.93	8.60
21.00	-4.07	16.54
24.00	-1.07	1.14
25.00	-0.07	0.00
26.00	0.93	0.87
22.00	-3.07	9.40
25.00	-0.07	0.00
23.00	-2.07	4.27
30.00	4.93	24.34
376.00	0.00	80.93
25.07		

SAMPLE 2	X- MEAN	$(x \text{ mean})^2$
EXPERIENCE		
24.00	-0.27	0.07
23.00	-1.27	1.60
24.00	-0.27	0.07
26.00	1.73	3.00
24.00	-0.27	0.07
25.00	0.73	0.54
27.00	2.73	7.47
26.00	1.73	3.00
26.00	1.73	3.00
25.00	0.73	0.54
20.00	-4.27	18.20
21.00	-3.27	10.67
24.00	-0.27	0.07
26.00	1.73	3.00
23.00	-1.27	1.60
SUM 364.00	0.00	52.93
MEAN 24.27		

SAMPLE 3	• X- MEAN	(x mean)^2
PLANNING		
21.00	-3.87	14.95
21.00	-3.87	14.95
22.00	-2.87	8.22
26.00	1.13	1.28
24.00	-0.87	0.75
28.00	3.13	9.82
21.00	-3.87	14.95
27.00	2.13	4.55
24.00	-0.87	0.75
24.00	-0.87	0.75
28.00	3.13	9.82
31.00	6.13	37.62
24.00	-0.87	0.75
27.00	2.13	4.55
25.00	0.13	0.02
SUM		
373.00	0.00	123.73
MEAN		
24.87		

SAMPLE 4	X- MEAN	(x mean)^2
TIME		
29.00	3.20	10.24
29.00	3.20	10.24
28.00	2.20	4.84
22.00	-3.80	14.44
27.00	1.20	1.44
25.00	-0.80	0.64
24.00	-1.80	3.24
26.00	0.20	0.04
26.00	0.20	0.04
26.00	0.20	0.04
26.00	0.20	0.04
26.00	0.20	0.04
27.00	1.20	1.44
24.00	-1.80	3.24
22.00	-3.80	14.44

SUM 387.00	0.00	64.40	
MEAN 25.80			

observations	observation -mean	(ob- mean)^2
26.00	1.00	1.00
27.00	2.00	4.00
26.00	1.00	1.00
26.00	1.00	1.00
25.00	0.00	0.00
22.00	-3.00	9.00
28.00	3.00	9.00
21.00	-4.00	16.00
24.00	-1.00	1.00
25.00	0.00	0.00
26.00	1.00	1.00
22.00	-3.00	9.00
25.00	0.00	0.00
23.00	-2.00	4.00
30.00	5.00	25.00
24.00	-1.00	1.00
23.00	-2.00	4.00
24.00	-1.00	1.00
26.00	1.00	1.00
24.00	-1.00	1.00
25.00	0.00	0.00
27.00	2.00	4.00
26.00	1.00	1.00
26.00	1.00	1.00
25.00	0.00	0.00
20.00	-5.00	25.00
21.00	-4.00	16.00
24.00	-1.00	1.00
26.00	1.00	1.00
23.00	-2.00	4.00
21.00	-4.00	16.00
21.00	-4.00	16.00
22.00	-3.00	9.00
26.00	1.00	1.00
24.00	-1.00	1.00
28.00	3.00	9.00
21.00	-4.00	16.00
27.00	2.00	4.00

	24.00	-1.00	1.00
	24.00	-1.00	1.00
	28.00	3.00	9.00
	31.00	6.00	36.00
	24.00	-1.00	1.00
	27.00	2.00	4.00
	25.00	0.00	0.00
	29.00	4.00	16.00
	29.00	4.00	16.00
	28.00	3.00	9.00
	22.00	-3.00	9.00
	27.00	2.00	4.00
	25.00	0.00	0.00
	24.00	-1.00	1.00
	26.00	1.00	1.00
	26.00	1.00	1.00
	26.00	1.00	1.00
	26.00	1.00	1.00
	26.00	1.00	1.00
	27.00	2.00	4.00
	24.00	-1.00	1.00
	22.00	-3.00	9.00
mean	25.00		
sum		Sum od squares total	340.00

total sum of squares	340.00
sum of squares within	322.00
sum of squares between	18.00

final calculations

$$\frac{sum\ of\ squares\ between}{degree\ of\ freedom}$$

	18.00	107.33
	3.00	

$$\frac{sum\ of\ squares\ within\ groups}{degree\ of\ freedom}$$

	322.00	5.75
	56.00	

f CRITICAL	18.67
f value from chart	2.77
f critical > f obtained	we fail to reject null hypothesis

As we fail to reject the null hypothesis, it clearly indicates that these variables are responsible for affecting the quality. The interCEPT now, holds a position to be considered in the further study. If the null hypothesis would have been rejected, it would mean that the factors that are being used to evaluate quality in construction are not related to quality itself. Anova method specifically does the one job of defining if or not the study is feasible. From the result of anova, the objective tests of SPSS and fuzzy logic can be derived. Which will be studied later in the project.

In many researches the ANOVA test is accompanied by the t-tests and the other ad-hoc tests to determine the degree and details of the relations, nut as this study includes SPSS for the purpose of finding out in details about the interrelation, correlations means, deviations, and analysis, the ad-hoc tests for anova would prove futile.

Table of critical values for the F distribution (for use with ANOVA:

How to use this table:

The table one gives critical values of F at the p = 0.05 level of significance. Obtain the F-ratio. This has (x,y) degrees of freedom related with it. Along x columns, and down y rows. The point of intersection is critical "F-ratio". If the obtained value of "F" is equal to or larger than this critical "F-value", then the result is significant at that level of probability.

Critical values of F for the 0.05 significance level:

	1	2	3	4	5	6	7	8	9	10
1	161.45	199.50	215.71	224.58	230.16	233.99	236.77	238.88	240.54	241.88
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.39	19.40
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14
10	4.97	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98
11	4.84	3.98	3.59	3.36	3.20	3.10	3.01	2.95	2.90	2.85
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49
17	4.45	3.59	3.20	2.97	2.81	2.70	2.61	2.55	2.49	2.45
18	4.41	3.56	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35
21	4.33	3.47	3.07	2.84	2.69	2.57	2.49	2.42	2.37	2.32
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.38	2.32	2.28
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.26
25	4.24	3.39	2.99	2.76	2.60	2.49	2.41	2.34	2.28	2.24
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.17
31	4.16	3.31	2.91	2.68	2.52	2.41	2.32	2.26	2.20	2.15
32	4.15	3.30	2.90	2.67	2.51	2.40	2.31	2.24	2.19	2.14
33	4.14	3.29	2.89	2.66	2.50	2.39	2.30	2.24	2.18	2.13
34	4.13	3.28	2.88	2.65	2.49	2.38	2.29	2.23	2.17	2.12
35	4.12	3.27	2.87	2.64	2.49	2.37	2.29	2.22	2.16	2.11

36	4.11	3.26	2.87	2.63	2.48	2.36	2.28	2.21	2.15	2.11
37	4.11	3.25	2.86	2.63	2.47	2.36	2.27	2.20	2.15	2.10
38	4.10	3.25	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09
39	4.09	3.24	2.85	2.61	2.46	2.34	2.26	2.19	2.13	2.08
40	4.09	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08
41	4.08	3.23	2.83	2.60	2.44	2.33	2.24	2.17	2.12	2.07
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.07
43	4.07	3.21	2.82	2.59	2.43	2.32	2.23	2.16	2.11	2.06
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05
45	4.06	3.20	2.81	2.58	2.42	2.31	2.22	2.15	2.10	2.05
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.15	2.09	2.04
47	4.05	3.20	2.80	2.57	2.41	2.30	2.21	2.14	2.09	2.04
48	4.04	3.19	2.80	2.57	2.41	2.30	2.21	2.14	2.08	2.04
49	4.04	3.19	2.79	2.56	2.40	2.29	2.20	2.13	2.08	2.03
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03
51	4.03	3.18	2.79	2.55	2.40	2.28	2.20	2.13	2.07	2.02
52	4.03	3.18	2.78	2.55	2.39	2.28	2.19	2.12	2.07	2.02
53	4.02	3.17	2.78	2.55	2.39	2.28	2.19	2.12	2.06	2.02
54	4.02	3.17	2.78	2.54	2.39	2.27	2.19	2.12	2.06	2.01
55	4.02	3.17	2.77	2.54	2.38	2.27	2.18	2.11	2.06	2.01
56	4.01	3.16	2.77	2.54	2.38	2.27	2.18	2.11	2.05	2.01
57	4.01	3.16	2.77	2.53	2.38	2.26	2.18	2.11	2.05	2.00
58	4.01	3.16	2.76	2.53	2.37	2.26	2.17	2.10	2.05	2.00
59	4.00	3.15	2.76	2.53	2.37	2.26	2.17	2.10	2.04	2.00
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99
61	4.00	3.15	2.76	2.52	2.37	2.25	2.16	2.09	2.04	1.99
62	4.00	3.15	2.75	2.52	2.36	2.25	2.16	2.09	2.04	1.99
63	3.99	3.14	2.75	2.52	2.36	2.25	2.16	2.09	2.03	1.99
64	3.99	3.14	2.75	2.52	2.36	2.24	2.16	2.09	2.03	1.98
65	3.99	3.14	2.75	2.51	2.36	2.24	2.15	2.08	2.03	1.98
66	3.99	3.14	2.74	2.51	2.35	2.24	2.15	2.08	2.03	1.98
67	3.98	3.13	2.74	2.51	2.35	2.24	2.15	2.08	2.02	1.98
68	3.98	3.13	2.74	2.51	2.35	2.24	2.15	2.08	2.02	1.97
69	3.98	3.13	2.74	2.51	2.35	2.23	2.15	2.08	2.02	1.97
70	3.98	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.02	1.97
71	3.98	3.13	2.73	2.50	2.34	2.23	2.14	2.07	2.02	1.97
72	3.97	3.12	2.73	2.50	2.34	2.23	2.14	2.07	2.01	1.97
73	3.97	3.12	2.73	2.50	2.34	2.23	2.14	2.07	2.01	1.96
74	3.97	3.12	2.73	2.50	2.34	2.22	2.14	2.07	2.01	1.96
75	3.97	3.12	2.73	2.49	2.34	2.22	2.13	2.06	2.01	1.96
76	3.97	3.12	2.73	2.49	2.34	2.22	2.13	2.06	2.01	1.96
77	3.97	3.12	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.96
78	3.96	3.11	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.95
79	3.96	3.11	2.72	2.49	2.33	2.22	2.13	2.06	2.00	1.95
80	3.96	3.11	2.72	2.49	2.33	2.21	2.13	2.06	2.00	1.95
81	3.96	3.11	2.72	2.48	2.33	2.21	2.13	2.06	2.00	1.95
82	3.96	3.11	2.72	2.48	2.33	2.21	2.12	2.05	2.00	1.95
83	3.96	3.11	2.72	2.48	2.32	2.21	2.12	2.05	2.00	1.95
84	3.96	3.11	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.95
85	3.95	3.10	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.94

86	3.95	3.10	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.94
87	3.95	3.10	2.71	2.48	2.32	2.21	2.12	2.05	1.99	1.94
88	3.95	3.10	2.71	2.48	2.32	2.20	2.12	2.05	1.99	1.94
89	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94
90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94
91	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.98	1.94
92	3.95	3.10	2.70	2.47	2.31	2.20	2.11	2.04	1.98	1.94
93	3.94	3.09	2.70	2.47	2.31	2.20	2.11	2.04	1.98	1.93
94	3.94	3.09	2.70	2.47	2.31	2.20	2.11	2.04	1.98	1.93
95	3.94	3.09	2.70	2.47	2.31	2.20	2.11	2.04	1.98	1.93
96	3.94	3.09	2.70	2.47	2.31	2.20	2.11	2.04	1.98	1.93
97	3.94	3.09	2.70	2.47	2.31	2.19	2.11	2.04	1.98	1.93
98	3.94	3.09	2.70	2.47	2.31	2.19	2.10	2.03	1.98	1.93
99	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03	1.98	1.93
100	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03	1.98	1.93

Table 6: F value reference chart

6.6 SPSS

SPSS stands for Statistical Package For The Social Sciences**.** It has been in market for more than thirty years. It is now used for analysis of variance, multiple regressions and general linear models for simple integers, binary variables and multiple responses or logarithmic variables. The package is particularly used for students and researchers in psychology , sociology, and other behavioral sciences.

After performing the ANOVA test to confirm that the variables actually affect the quality of construction. SPSS can be used to find the relation and trends of the variables and fashion with which that affect the quality. This can be done by using t-tests, which are the ad-hoc tests to ANOVA, but SPSS proves to be a better alternative for the purpose of analysis.

The analysis is done in a series of steps and different operations on the software. The values are put in form of digits or string values. The string values must be converted into digits to carry analysis as the analysis can only be done in between the digital database and not the statement database. For the analysis, it is important to know the SPSS software. SPSS provides with a broad range of capabilities for the entire analytical process. With SPSS, user can generate decision-making information quickly using powerful statistics, understand and effectively present your results with high-quality tabular and graphical output, share your results with others using a variety of reporting methods, and take advantage of the analytical asset storage and deployment capabilities of other SPSS products. Results from your data analysis enable you to make smarter decisions more quickly by uncovering key facts, patterns, and trends

6.6.1 THE SOFTWARE

The software contains a set of views to ease the analysis and to define the variables and the outcomes.

VARIABLE VIEW: located in the bottom of the page, it contains the definitions of each of the variable in the data set, including the names, type of the variable, alignment and other related information. While the variables are listed in the columns in data view, they are listed in rows in variable views.

OUTPUT VIEW: the output window contains the result of the analysis that has been carried. The output contains the information of the frequency distribution, cross tabs and other statistical methods. The output windows pops up every time an analysis is done.

THE DRAFT VIEW: Is used to look at output as it is generated for printing.

THE SYNTAX VIEW: The syntax view is used to store the steps that were performed for the analysis.

6.6.2 ANALYSIS IN S.P.S.S

To analyze the trends in variables a couple of tests are carried out n variables which includes solo tests, comparative tests and relation tests. The analysis carried out in this study are of following types:

- Graphical
- Co-relation
- Mean

CO-RELATION: this analysis is specifically used to determine the co-dependency of two or more variables. Firstly only a case of two variables is to be considered. The variables are then classified as independent and dependent variables. the test then is used to find positive and negative co-relation.

A positive co relation occurs when due to increase or decrease in value of an independent variable the value of the dependent variable follows the same fashion. Increase to increase and decrease to decrease.
A negative co relation occurs when due to increase or decrease in value of an independent variable the value of the dependent variable follows the opposite fashion. Increase to decrease and decrease to increase.
If the co-relation value from the SPSS data entry is positive number closer to +1, the relation is a strong positive correlation, similarly if the co-relation value is a number closer to -1, then the co relation is said to be strong negative co-relation. As the study was besed on the questionnaires the variables are to be correlated using Spearman and Kendalf co-relate coefficients. If the variables were not based on the questionnaire but simple distribution with uniform variation, then Pearson's coefficients are used.

The correlations are as follows.

- **Cost- planning correlation** : the cost planning correlation suggests logically that if the planning is done well, then the cost for the project can be reduced. In other words, if the rating given by the respondents to planning is less, it would suggest that the cost of the project would be significantly greater.

  This observation is aslo observed using the SPSS SOFTWARE. The ratings of the respondents were feeded to the system as inputs and pearson and kendalff coefficinets were used to find the correlation. It was found out that the variables have a negative co-relation. A negative correlation means that when the value of one variable increases the value of the other variable decreases. This was visible in the output window. It the planning is increases to optimum level, the cost of the project was reduced. This reading was supported by the respondents during the questionnaire. The respondents who gave planning importance were found out to experienced professionals and the cost was given least importance because the cost can be controlled by planning. On the other hand, if cost was given importance then the work is designed to revolve around the cost bracket, which usually, in the end stage of project leads to unforeseen expenses.

  So it can be concluded that if planning is done properly then the cost factor is automatically handled. Unfortunately, this cannot be said in the reverse manner. If cost is ample then it is not necessary that the planning will be well, however it is suggested that a person with high cost bracket should hire a professional project planner.

Table 7: co-relation table between cost and planning

Nonparametric Correlations

Correlations

			PLANNING	COST
Kendall's tau_b	PLANNING	Correlation Coefficient	1.000	-.491*
		Sig. (2-tailed)	.	.015
		N	16	16
	COST	Correlation Coefficient	-.491*	1.000
		Sig. (2-tailed)	.015	.
		N	16	16
Spearman's rho	PLANNING	Correlation Coefficient	1.000	-.585*
		Sig. (2-tailed)	.	.017
		N	16	16
	COST	Correlation Coefficient	-.585*	1.000
		Sig. (2-tailed)	.017	.
		N	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

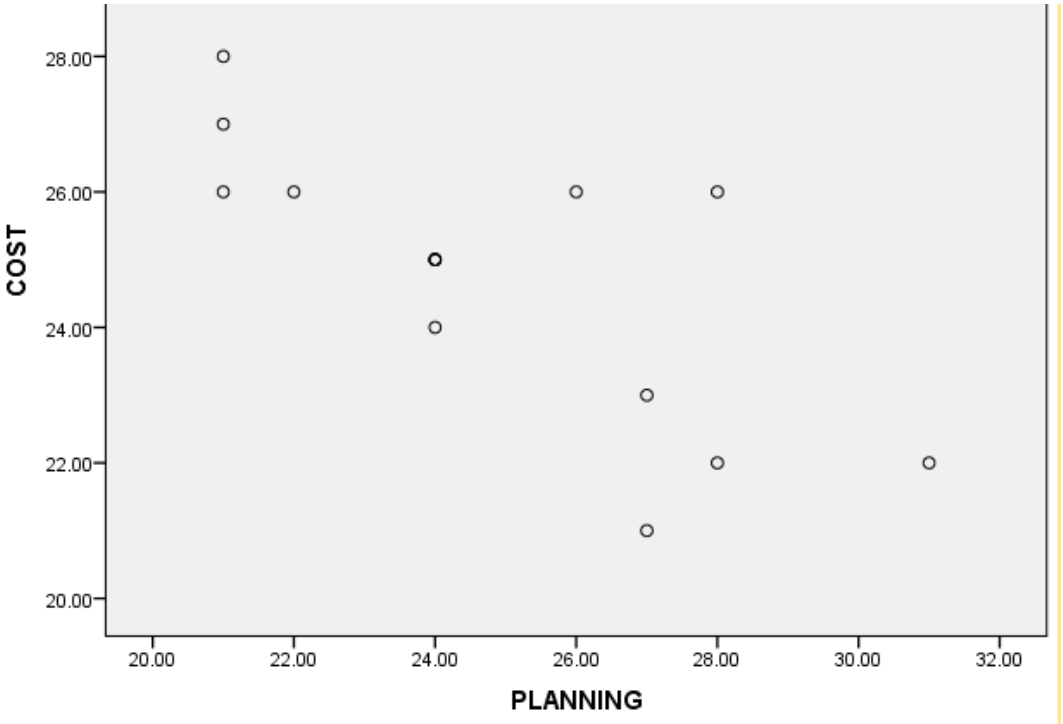


Figure 5 : cost and planning scatter graph

- **Planning –time correlation.**

  The planning and time correlation is also negative correlation. However, to clearlt define the correlation one has to consider two cases.

  CASE 1 *Planning Reduces Time Of Construction*. In this case it is assumed that good planning not only reducs the cost of the construction bur also the time is reduced. Good planning makes the maximum possible number of works that can be done simultaneously, execute. Also the process that are dependent on the preceding works are lined up reducing the lags. Considering this on a large scale a lot of time can be saved. In the case when most of the works is done by labours or to say in rural areas. Planning is necessary to keep the work in a continuous pace considering daily working hours, over shifts and fatigue. So it can be said that planning reduces time of construction.

  CASE 2 *Planning Is Dependent On Time As An Input:* it cannot be ignored that planning required time constraints and labour and material constraints. The most important of the constraints is the time constraint, as if directly affects the planning. If there are not labour and material constraints then the work can be carried out as fast as the work is done. However, in cases like curing and setting of concrete and fixture and fastening, where time is needed for the process to complete itself, the succeeding work cannot be done without the previous work ending up first. This suggests that planning is directly related to time. Also, it time is not restrained the planning then will be done to reduce cost.

  It can be done in number of ways like, hiring workforce that is cheaper than the machines but takes up considerable amount of time. Feasibility has to be done to check if the work that can be completed by a machine (say excavation) takes a day and some money. Can a couple of men do this same work in a week and is the cost still the same? Is it advisable to hire men for excavation considering the wages per day for the week and safety aspects? Same kind of analysis goes side by side with other aspects of construction and planning. Assuming that in todays construction work time cannot be restrained, for the analysis no specific constraint is considered and will be considered after the spss analysis. As not both of the constraints can be proved simultaneously. Only one of the two will be proved and the other will have to be rejected with a valid reason.

Correlations

			PLANNING	TIME
Kendall's tau_b	PLANNING	Correlation Coefficient	1.000	-.440*
		Sig. (2-tailed)	.	.030
		N	16	16
	TIME	Correlation Coefficient	-.440*	1.000
		Sig. (2-tailed)	.030	.
		N	16	16
Spearman's rho	PLANNING	Correlation Coefficient	1.000	-.536*
		Sig. (2-tailed)	.	.032
		N	16	16
	TIME	Correlation Coefficient	-.536*	1.000
		Sig. (2-tailed)	.032	.
		N	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

Table 7 : planning and time co-relation.

The negative values suggests that the relation between the variables is a negative correlation. This suggests that good planning can reduce the time of the completion of project.

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6.7 FUZZY LOGIC

Fuzzy logic can be defined as a multivalued logic, which allows the intermediate values to be defined between conventional evaluations like yes/no or true/false. Notions like very good, good, fairly good can be expressed by fuzzy logic approach. Fuzzy logic also helps in finding the relations and eventually help in artificial intelligence. By artificial intelligence, it is meant that software for projecting the quality standard provided the scores of the variables. The very notion of fuzzy logic is to provide detail to the crisp logic. A crisp logic is when the values of a set is either 1 or 0. But in a fuzzy logic set , the values can exist in between 0 to 1. In fuzzy logic a set of inputs are considered that are then acted upon by a set of conditions or combinations and result in a set of different outputs. The fuzzy analysis follows the following steps:

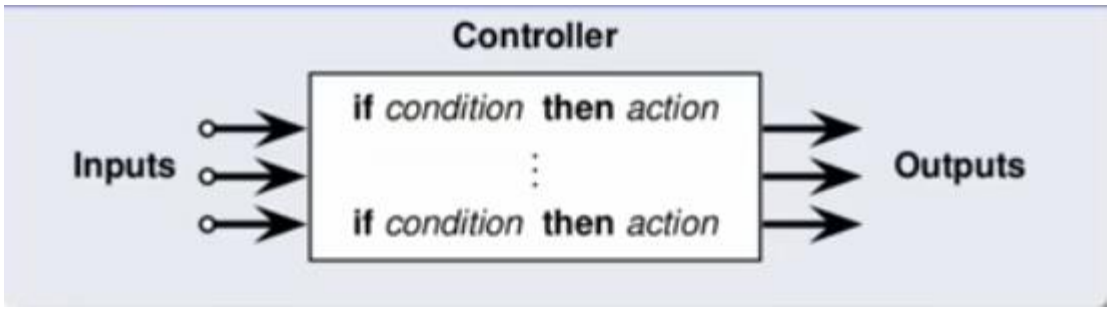


Figure: 6 Fuzzy logic process

FUZZIFICATION: the conversion of crisp sets into fuzzy sets.

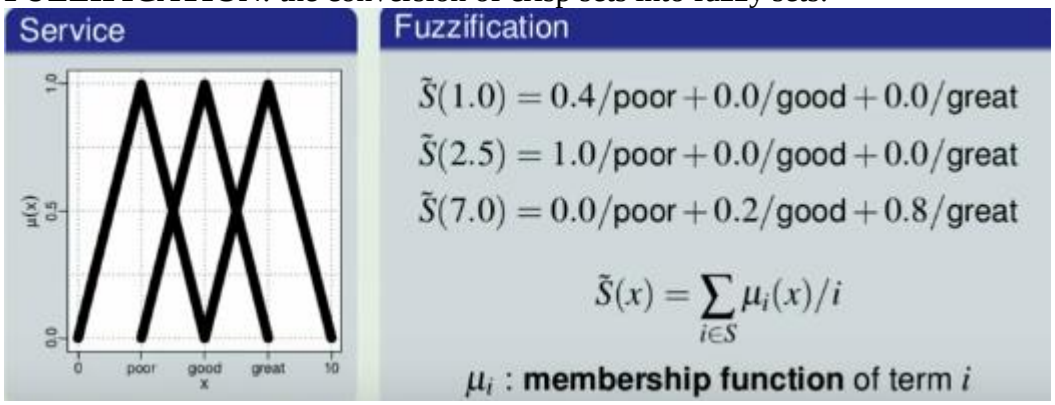


Figure 7: Fuzzification

INFERENCE: the process of activation of rules to generate fuzzy sets. In this process we assign the values from membership function to the corresponding end function. This is accompanied by modification of consequence. Where the fuzzified values are multiplied with the function values.

Defuzzification : the values obtained by the inference are then converted in to crisp values such as good, average and bad. To obtain the end result of the simulation.

When there is an understanding that quality is followed or not, the result is either yes or no. This is an example of crisp logic where the values range only either 1 (yes) or no (0). But if we approach the same situation with fuzzy logic, the responses can be numerous, for example:

- Yes (1)
- Fairly Applied (Say 0.9)
- Sometimes (Say 0.8)
- Rarely (0.5)
- Never (0)

as you can see the values range from 0 to 1, and this is the set for fuzzy logic. All the values of the responses laying in between 0 and 1 are in the set of fuzzy control, also called as fuzzy control set. To understand FUZZY LOGIC let us consider a system whose output depends on the input and the user can modify the system by a set of rules. Say, input A is x and input B is y leading to output z, fuzzy logic control is very effective for this type of analysis. The methodology of the research is

same to this approach as the output is the quality and the inputs are the four variables that affect the quality so the software can be used to analyze the fuzzy control. The process of fuzzy logic can be understood by the following representation. For the purpose of analysis a program for fuzzy sets is used, *QTFUZZYLITE* .

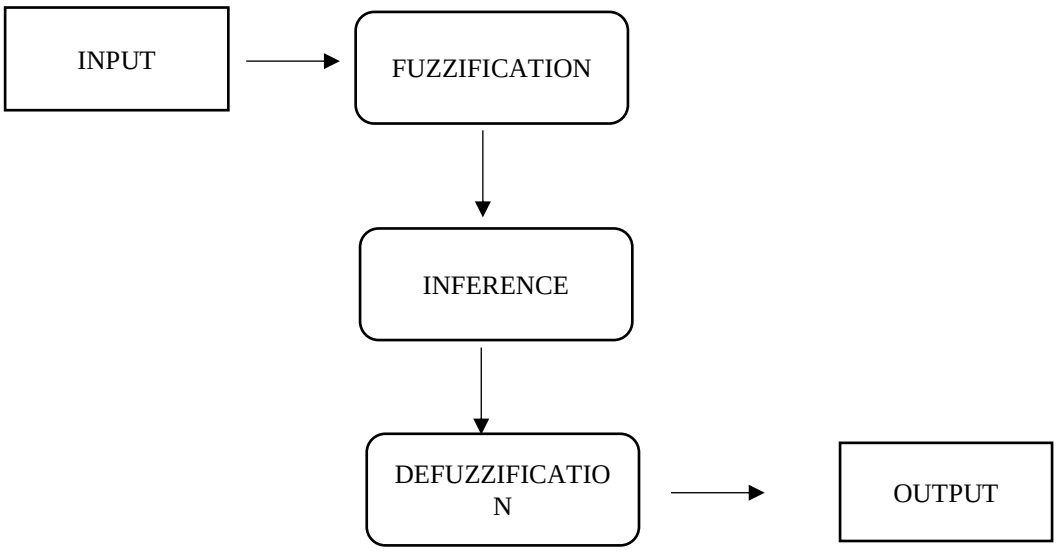


Figure 8: Flow Chart Of Fuzzy Logic Process

6.8 QTFUZZY LITE

Qtfuzzylite is an open source free QT application to perform the fuzzy logic control. It works on Microsoft C++ library to perform the algorithms. The software will need a set or a fuzzy set to work upon. In this study the fuzzy set is of variables that affect the quality in construction.

To explain a slight working methodology and principle of fuzzy logical program consider this. The four variables COST, EXPERIENCE, PLANNING, TIME affect the quality so, let us group these variables as inputs for quality and study what happens. Most common case is when all the variables are in adequacy. Meaning that the respondent had ample of money available to spend on the services, had ample of experience, there is no time brackets on the project and the respondent is good planner. It , in this case is fairly obvious to assume that the quality of construction is going to be good.

- In another case when the cost is less, the planning is poor , the respondent is new to the job and there is a short time bracket for the job. The quality will be poor as compared to the above stated conditional quality.
- In another case when the investment is less but the respondent is skilled and experience, time is in excess. The respondent can still provide with satisfactory quality work.
- In another case when the experience is less but the respondent has good planning skill and the cost and time are in excess the quality of construction can be fairly good, as compared to the worst conditions.

So considering these four cases we achieve different levels of quality satisfactions, further if we divide each of the variable into five scales, excellent, good, fair, bad, worst respectively and assign values 5,4,3,2,1 to these responses. Simultaneously giving these values to all four of the factors we can have a combination of 625 different cases. An example of a simple combination of quality and cost can be represented as follows.

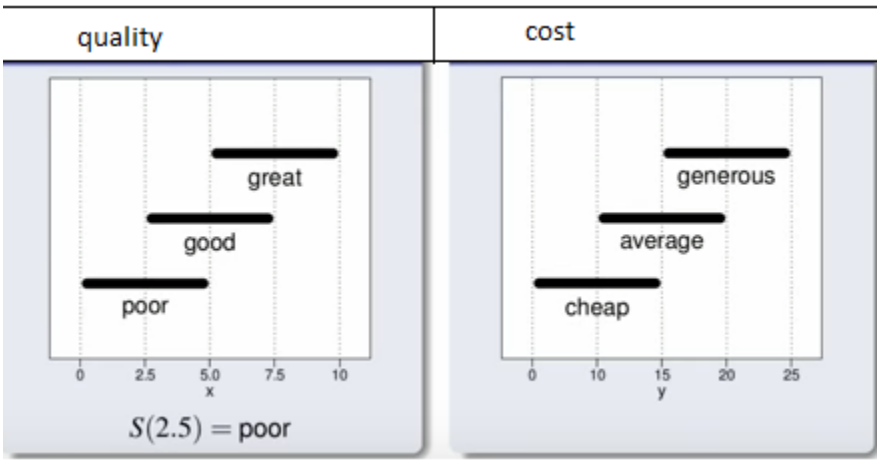


Figure 9: Input Values For Quality And Cost

6.8.1 INPUT

The inputs for the software are the variables that affect the quality, *interCEPT* it the combined term to use these variables as in this study. The variables are then given a scale from 1- 10 for each variable and different crist values are allocated with them.

COST the variables for cost are:

- Limited cost investment, it includes cost just necessary for the procedure disregarding the contingencies and mishaps, for the rural areas mostly this variable of cost is to be considered.
- Adequate cost investment, it includes cost of the project in addition to contingencies. The urban small-scale works are done using this cost.
- Surplus cost investment, large construction with greater risks in time and efficiency requires additional costs in form of investments and assets so as to cope with time restraints and advancements and market fluctuations.

EXPERIENCE as stated earlier experience is not necessarily always the good type, a work being done in a wrong way but for 50 years adds to 50 years of wrong experience and so experience is so very critical in this study. However, it is assumed that the experience considered here is related to the work and is in positive direction. The values for experience in the fuzzy logic control are

- Low: meaning that the respondent has had experience from 0-5 years. Tough it may be satisfactory for small and medium scale works it cannot be stated that an experience for a large scale work can be easily and satisfactorily be done by a new employee or an employee with low experience.
- Average experience : 6-15 years of experience in same or similar kind of work profile is considered as an average for the sake of the study.
- High: any respondent with working experience more than 15 years is considered to be having high experience in the field of work. And a an with great experience can be suited for a job with worst possible conditions to receive adequate level of quality and also in a situation where the conditions are optimal and the level of quality to be attained is optimum.

PLANNING: planning, in the study can be considered to have only two crisp values. Either the respondent is good in planning or not so good in planning. Which would mean that in the project , there is either no planning, fairly planned or well planned.

TIME: time can only be limited or unlimited, which means that either the wok is restricted in time constraints or it is not, and so in this study it has two values for the analysis.

6.8.2 RULES

the software required rules for running the fuzzy logic simulation. These rules defines the relations between the variables. To get to a conclusion, the program will make every possible relation between the variables. The variables need to have values that will represent the graph. The variable are however not quantitative, i.e. they do not have natural numeric values. For example planning does not have a scale value, it is either good planning or bad planning. So these string values are to be converted into numeric values. This process is known as defining the variable and this is done in the

entering variable window of the program. Bad is given value "0" and good is assigned value "1". Then the rules are dictated to the computer based upon the findings from SPSS.

for example if cost is less and time is less with poor planning and no experience the level of quality will be low. This is a single set of rule with values of COST, EXPERIENCE, PLANNING and TIME being minimum. The total number of rule to be defined in this study are 54, considering all the possible combinations. The rules are listed below.

1. if cost is limited and experience is low and planning is no and time is limited then quality is minimal.
2. if cost is limited and experience is low and planning is no and time is unlimited then quality is minimal.
3. if cost is limited and experience is low and planning is poor and time is limited then quality is minimal.
4. if cost is limited and experience is low and planning is poor and time is unlimited then quality is minimal.
5. if cost is limited and experience is low and planning is well and time is limited then quality is fair.
6. if cost is limited and experience is low and planning is well and time is unlimited then quality is low.
7. if cost is limited and experience is average and planning is no and time is limited then quality is low.
8. if cost is limited and experience is average and planning is no and time is unlimited then quality is minimal.
9. if cost is limited and experience is average and planning is poor and time is limited then quality is low.
10. if cost is limited and experience is average and planning is poor and time is unlimited then quality is low.
11. if cost is limited and experience is average and planning is well and time is limited then quality is fair.
12. if cost is limited and experience is average and planning is well and time is unlimited then quality is good.
13. if cost is limited and experience is high and planning is no and time is limited then quality is fair.
14. if cost is limited and experience is high and planning is no and time is unlimited then quality is fair.
15. if cost is limited and experience is high and planning is poor and time is limited then quality is fair.
16. if cost is limited and experience is high and planning is poor and time is unlimited then quality is good.
17. if cost is limited and experience is high and planning is well and time is limited then quality is excellent.
18. if cost is limited and experience is high and planning is well and time is unlimited then quality is excellent.
19. if cost is adequate and experience is low and planning is no and time is limited then quality is minimal.
20. if cost is adequate and experience is low and planning is no and time is unlimited then quality is low.

21. if cost is adequate and experience is low and planning is poor and time is limited then quality is low.
22. if cost is adequate and experience is low and planning is poor and time is unlimited then quality is fair.
23. if cost is adequate and experience is low and planning is well and time is limited then quality is fair.
24. if cost is adequate and experience is low and planning is well and time is unlimited then quality is good.
25. if cost is adequate and experience is average and planning is no and time is limited then quality is low.
26. if cost is adequate and experience is average and planning is no and time is unlimited then quality is fair.
27. if cost is adequate and experience is average and planning is poor and time is limited then quality is low.
28. if cost is adequate and experience is average and planning is poor and time is unlimited then quality is fair.
29. if cost is adequate and experience is average and planning is well and time is limited then quality is good.
30. if cost is adequate and experience is average and planning is well and time is unlimited then quality is excellent.
31. if cost is adequate and experience is high and planning is no and time is limited then quality is good.
32. if cost is adequate and experience is high and planning is no and time is unlimited then quality is good.
33. if cost is adequate and experience is high and planning is poor and time is limited then quality is fair.
34. if cost is adequate and experience is high and planning is poor and time is unlimited then quality is fair.
35. if cost is adequate and experience is high and planning is well and time is limited then quality is excellent.
36. if cost is adequate and experience is high and planning is well and time is unlimited then quality is good.
37. if cost is surplus and experience is low and planning is no and time is limited then quality is minimal.
38. if cost is surplus and experience is low and planning is no and time is unlimited then quality is low.
39. if cost is surplus and experience is low and planning is poor and time is limited then quality is low.
40. if cost is surplus and experience is low and planning is poor and time is unlimited then quality is fair.
41. if cost is surplus and experience is low and planning is well and time is limited then quality is good.
42. if cost is surplus and experience is low and planning is well and time is unlimited then quality is good.
43. if cost is surplus and experience is average and planning is no and time is limited then quality is fair.

44. if cost is surplus and experience is average and planning is no and time is unlimited then quality is good
45. if cost is surplus and experience is average and planning is poor and time is limited then quality is fair.
46. if cost is surplus and experience is average and planning is poor and time is unlimited then quality is fair.
47. if cost is surplus and experience is average and planning is well and time is limited then quality is good.
48. if cost is surplus and experience is average and planning is well and time is unlimited then quality is good.
49. if cost is surplus and experience is high and planning is no and time is limited then quality is low.
50. if cost is surplus and experience is high and planning is no and time is unlimited then quality is fair.
51. if cost is surplus and experience is high and planning is poor and time is limited then quality is fair.
52. if cost is surplus and experience is high and planning is poor and time is unlimited then quality is good.
53. if cost is surplus and experience is high and planning is well and time is limited then quality is excellent.
54. if cost is surplus and experience is high and planning is well and time is unlimited then quality is excellent.

The readings of the software are given below.

CASE 1

INPUTS: the values of the variables entered into the fuzzy logic system to observe the trend is listed below.

Cost: low capital investment

Experience: low experienced professional

Planning: un-planned out work

Time: the project is restricted by time limits

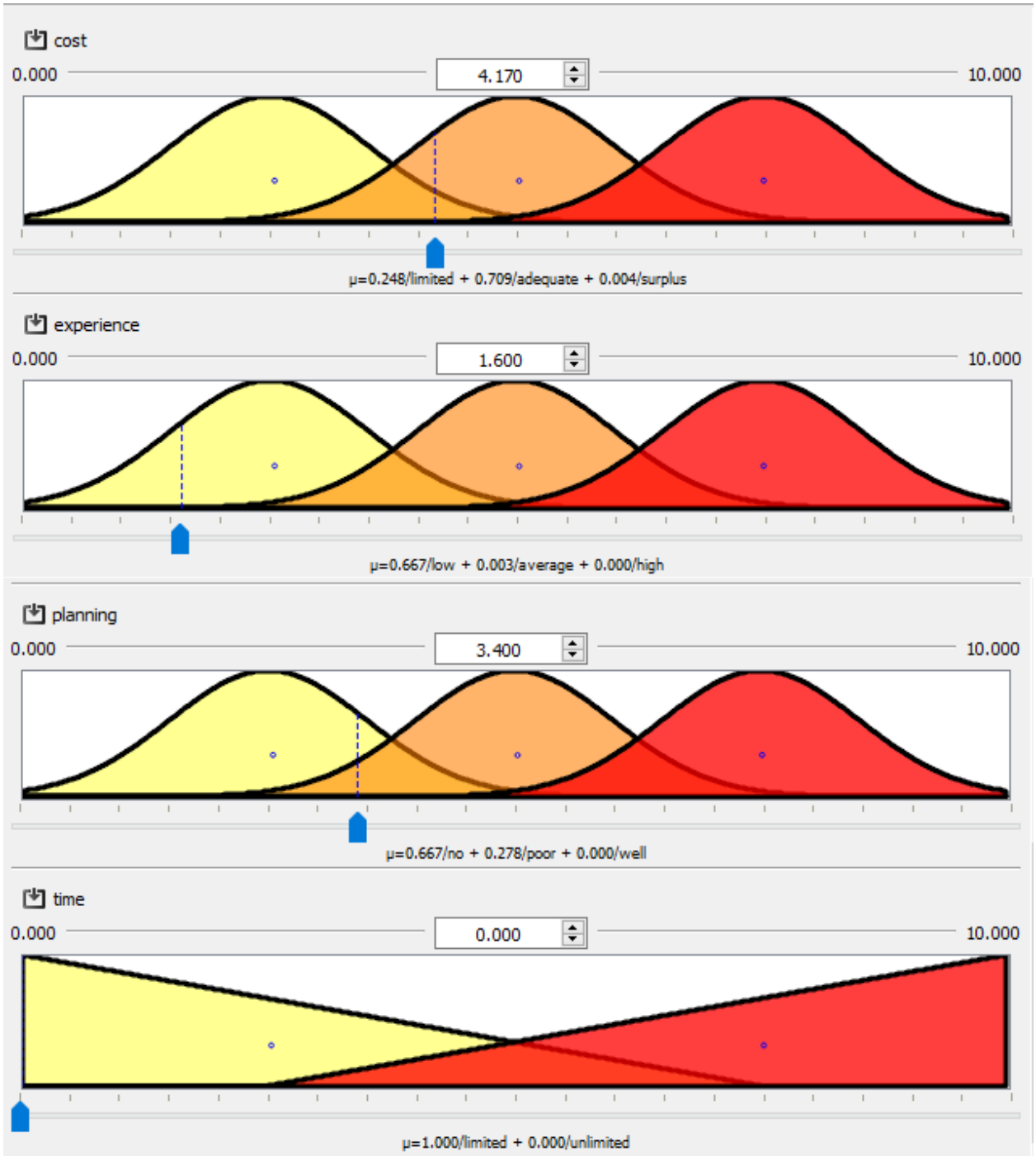


Figure 10: Input Variable Values For Fuzzy Simulation

OUTPUT:

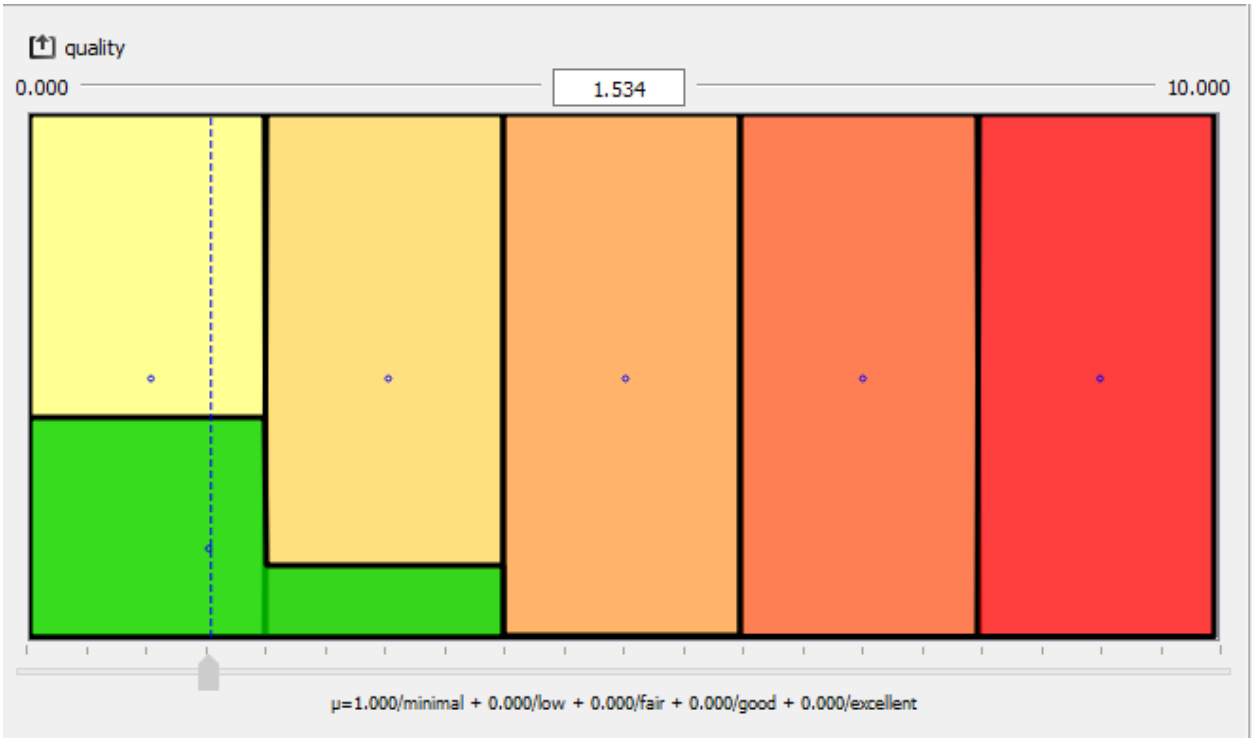


Figure 11: Output Window For Fuzzy Simulation

From the settings that were included in the fuzzy logic system it is clear that by providing minimal variable values to the input window, the level of quality satisfaction is low.
The values of quality ranges from minimal to low quality observed. This supports out hypothesis that the variables have a direct effect on the quality in construction.

CASE 2:
INPUTS
The settings for this case are as follows.
Cost: high capital investment
Experience: highly experienced professional
Planning: well-planned out work
Time: the project is not restricted by time limits.

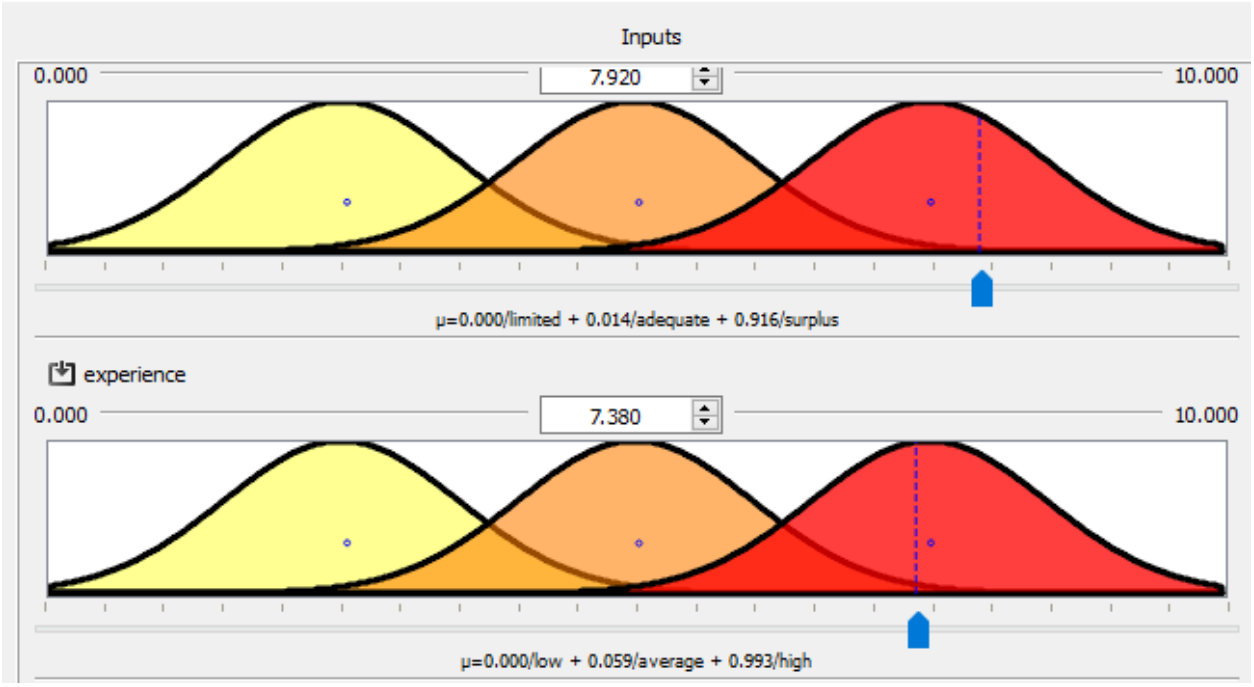


Figure 12: Input For Case 2 For Fuzzy Simulation

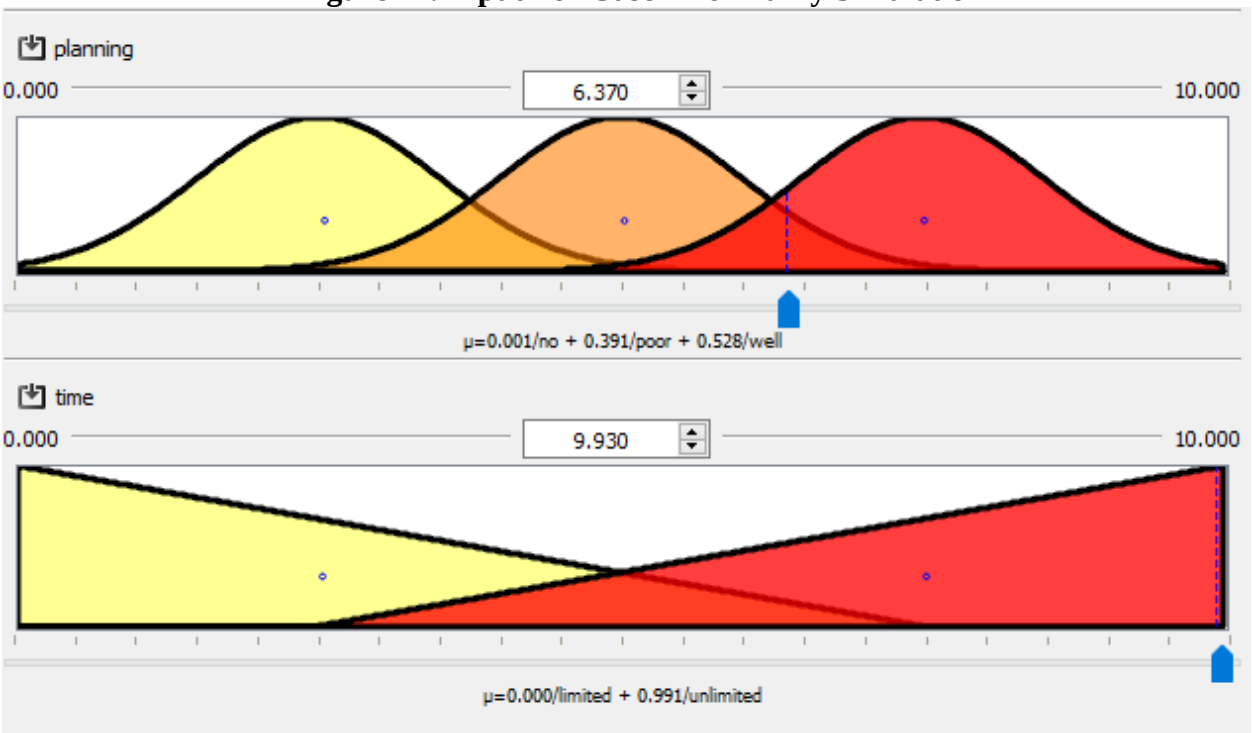


Figure 13 : Input For Case 2 For Fuzzy Simulation

OUTPUT: by providing the above mentioned settings it was observed that the quality of construction was observed to be of good and excellent standards. This proves out hypothesis as discussed in anova

that the variables affect the quality. Also it is observes that the bars are not completely filled and this is is because of the interrelation between the variables. the rules that were added during the fuzzy logic simulation program. Helps in determining the level of quality upon the act of various variables.

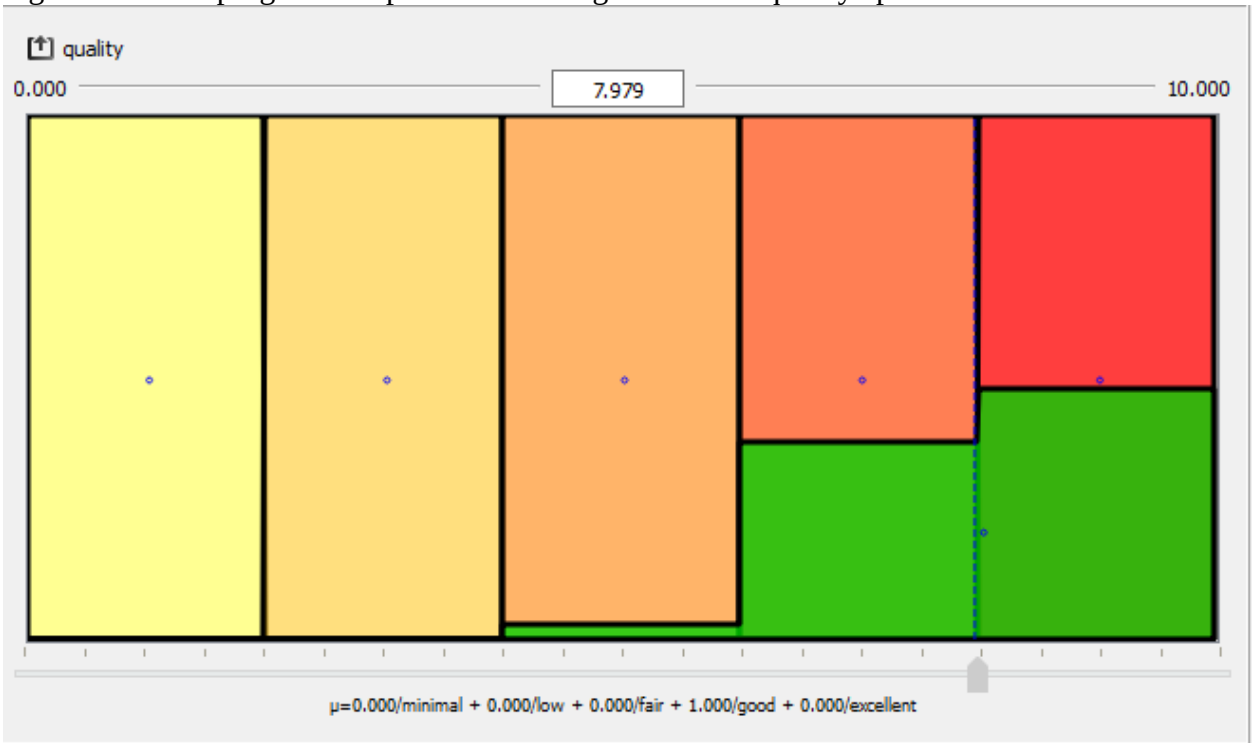


Figure 14: Output For Case 2

6.9 The Butterfly Effect

The butterfly effect states that a single very minor change in a situation can lead to a very drastic positive or negative result. This principle was initially used for weather prediction but later it was used for explaining various scientific and nonscientific happenings. The butterfly affect can be used to discuss the effects of variables on the quality of construction. As it was clear from the fuzzy logic output. The variable when changed slightly had an effect on the overall quality of the construction. This is supported by the fact that, construction contains minor and major processes that combine to give the end product. The quality of these minor and major products determine the overall quality of the service.

To consider a example of the butterfly effect. Consider the multilevel parking of the Shimla INTER TATE BUS TERMINAL. The process involves cutting of the hilly region to be levelled at a specific height. For load calculation and design of the foundations, soil properties were determined. There is a minor error in accounting for the seepage that occurs on the hill top region. It has been neglected because the drainage was very scarce and rain water was not observed for a couple of months. Now as it is clear that in hilly areas the drainage is almost natural. The flood water flows through the small valleys present in between the mountains and the hilly regions. For past almost million years the water was seeping through the soil into underground water table. This water was then reaching the natural drain. In the process the water eventually made the soil soft and plastic. Now due to the construction and excavation of the area below the highway when the large amount of the soil was removed. The areas eventually collapsed. The scale of landslide was around 100 cubic meters and more. This lead to delay in project as the soil now had to be excavate and reallocated, a new process for soil handling had to be introduced. Resources need to be allocated. And re-planning is to be done for the whole project ad a major contingency has occurred.

To graphically represent the butterfly effect let us take a look at the fuzzy simulation.

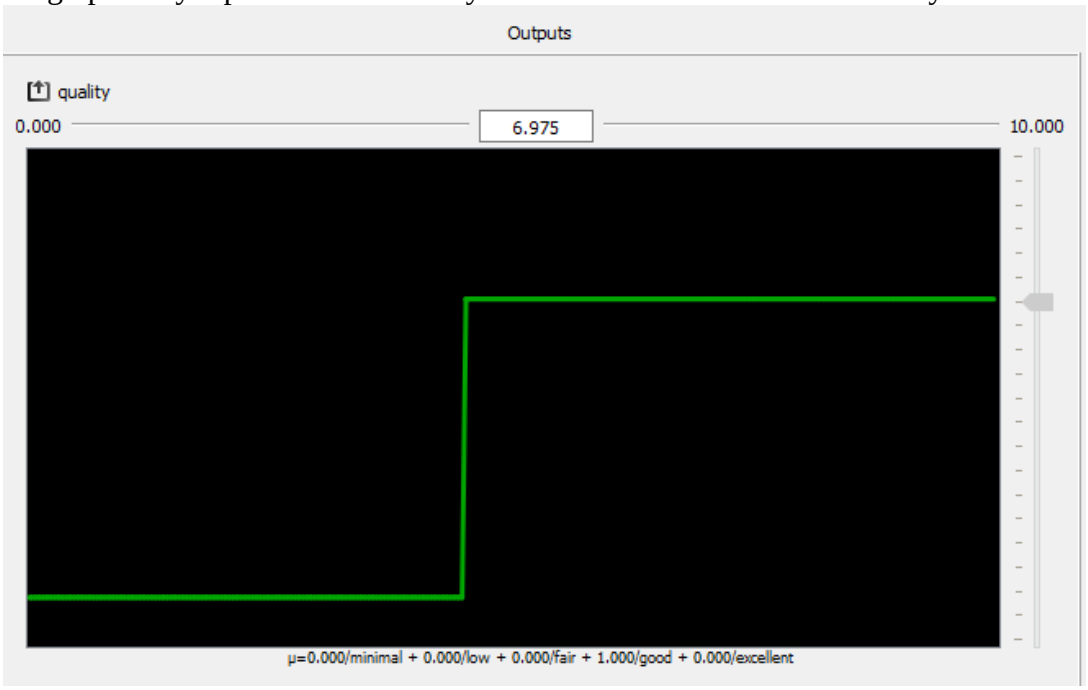
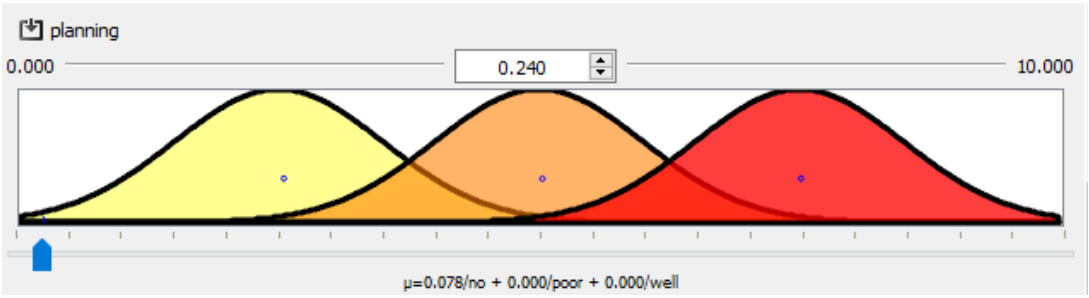


Figure 15: Output Depicting Butterfly Effect



The planning is not done for calculation and corresponds to the left half of the graph representing the quality in construction.

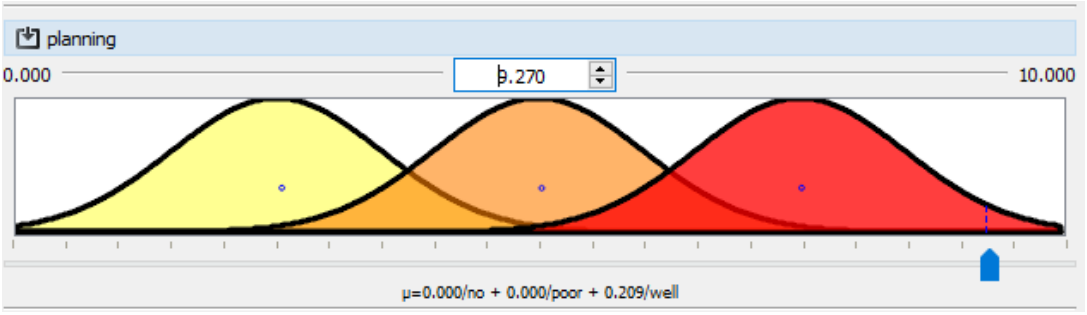


Figure 16: No planning and well planned input values.

The project is well planned with calculations and it corresponds to the right half of the quality output.

6.9 RESULTS OF STUDY

This section involves the details of all the results that were observed during the study. This includes the questionnaire, ANOVA results, SPSS, and the fuzzy logic software. As these all were to be discusses in series because each is related to the previous software and interrelated, the

6.9.1 QUESTIONNAIRE

The results of the questionnaire were classified in terms of delta values and performance table. Every respondent has allocated with him, a response table, a percentage chart relating to the variables, a bar chart representing the maximum values of the variables, and a delta value. A comparison of the delta values has been done to categorize the similar respondents to a group and better understand the trend in the construction quality process. This will lead to better prequalification if needed and selection of the respondent. The work accomplished suggests that there is a kind of relation between the variables and the delta values, variables in between. Upon further analysis of these variables and applying fuzzy logic, the relation can be clearly defined. From the questionnaire is clear that most of the respondents consider planning and experience as the most crucial factors.

6.9.2 ANOVA

The results of anova concluded that the variables have a strong affect on the quality in construction and cannot be neglected. It is after this anova result that the analysis was safe to b carries out by means of SPSS and fuzzy logic approach. Has the results of anova were different i.e if it stated that the variables do not have any significant effect on the quality of construction then the study would have been a ended at anova.

Anova also stated that there was a significant variance in between the variables and a significant variance within the variable discussed.

This meant that the variables not only affect the quality of construction but also the other variables , however this hypothesis cannot be sad to be on concrete grounds without doing the further analysis. The additional analysis were done by using the SPSS software to find out the relation and inter and co- dependency.

6.9.3 SPSS

SPSS was one of the most important tools to find the relation between the variables after concluding the anova results and then this analysis supported the interdependency and codependency of the variables. also SPSS was able to find out the means and the average ,the occurrence, range and regression.

6.9.4 Fuzzy Logic

fuzzy logic was used with setting the values for the critical factors to a scale from 1- 10 and defining the scale in between the divisions. These divisions were from poor to good, limited to unlimited. The results of fuzzy logic are vast. According to the software, the values for the inputs can take any value between 0-10 including and up to 2 decimal places and thus showing the effect of various alteration between the variable and the result that was observed on the quality as output. However, fuzzy logic was also dependent upon the anova analysis. In addition, SPSS provided strong evidence that the variable can be interrelated. The interrelation between these four variables was positive as well as

negative. The type of relations affect the fuzzy logical analysis. This was clear in the result window of the software. By varying the values of inputs viz COST EXPERIENCE, PLANNING AND TIME quality was effected in a nonlinear fashion showing the interdependency of the variables.

6. CONCLUSION

From this study carried out on the respondents from the rural areas, it can be concluded that the variables that affect the quality of a project can be classified as

- Manage Mental
- Contractor Variables
- Material Variables
- workforce variables

It is clear from the study that rural sectors of Indian construction industry needs to focus on

1. Education regarding the work,
2. Innovation in the processes of construction,
3. Focus on the safety of the workers, by giving importance to all these criteria, one can ensure quality to the project and satisfaction to the client.

- The study is comprised of two parts, the initial part was collection of data and designing of questionnaire and the second phase of the study, to collect the data from the questionnaire and convert it into numerical values and find exactly what are the variables that can be eliminated or utilized to improve the quality to its maximum efficiency. The second phase gave us knowledge about the variables, their real time effect on quality, analysis that concluded the importance and relations and hypothesis regarding the quality in construction work tested.

- From the study carried out, it is clear that quality can be affected by a number of conditions, procedures, specifications and much more, it is not necessary that the variables of quality always boost the quality or take down the quality, in some cases these variables are practically inert.

- The analysis showed clear signs of relations between the variables.

- The state of mind of the client will describe what kind of quality he needs. the variable is nonexistent for the rest of the working class, whatever be the state of mind of the contractor , the quality has to be achieved or he will not be paid well, same goes with the labour, being too excited or too sad or just normal psychologically will not affect the quality of project.

- The future work in this field is limitless, as the diversity in the construction sector increases there is a good chance of providing best quality with minimal efforts, this can only be done if we are able to determine the variables that affect the quality.

- The butterfly affect is considered in the study, because after obtaining the result from the analysis it is not necessary to change the working process but just a fragment of the attitude towards the working or the very minute working culture. It is assumed that a small positive change in the method can contribute to the overall quality of the project

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APPENDIX 1

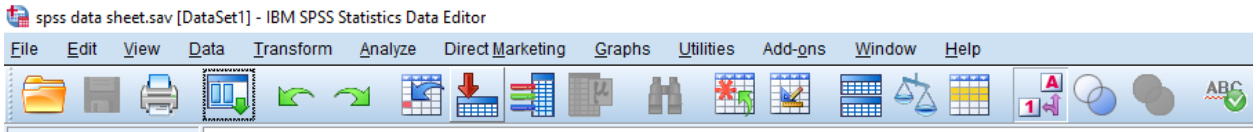
The appendix contains the survey results converted into numeric values and the charts prepared for purpose of the analysis by the software. Further the appendix contains elaborated inputs and results of the software used in the project.

SURVEY RESULTS:

The questionnaires were distribute among the respondents and the responses that were considered authentic are used for the analysis in this study. Suspicious and fake responses are dis regarded. Out of total 35 survey questionnaires only 20 were selected. These includes the responses but the engineers, foreman , workers, electrical carpenters etc. the graph on the response excel sheet represents the cumulative score of each of the factors considered using the *interCEPT*.

The pie chat emphasizes on the percentage contribution towards the working methodology of the respondent. This was helpful in determining the working trends of the respondents. The delta value is the total score obtained by adding all the obtained marks of the respondents and dividing it by the total maximum marks. The delta value is used to group the respondent in to categories and helps in classification of working profile of the respondent.

SPSS



	NAME	AGE	COST	EXPERIEN...	PLANNING	TIME	DELTA_VALUE	PREFFER...	ZAGE
1	AVTAR	49.00	26.00	24.00	21.00	29.00	64.07	TIME	1.04263
2	GAGAN	26.00	27.00	23.00	21.00	29.00	64.67	TIME	-1.28275
3	BABU RAM	42.00	26.00	24.00	22.00	28.00	65.86	TIME	.33491
4	BALJEET	30.00	26.00	26.00	26.00	22.00	70.05	COST	-.87834
5	SUNDER	50.00	25.00	24.00	24.00	27.00	70.65	TIME	1.14373
6	RAJ KUMA	35.00	22.00	25.00	28.00	25.00	71.25	PLANNING	-.37282
7	VINOD KU	40.00	28.00	27.00	21.00	24.00	71.85	COST	.13270
8	RAKESH T	22.00	21.00	26.00	27.00	26.00	71.85	PLANNING	-1.68716
9	DURGESH	30.00	24.00	26.00	24.00	26.00	73.65	EXPERIEN...	-.87834
10	SOHAN SI	50.00	25.00	25.00	24.00	26.00	76.64	TIME	1.14373
11	MADAN	50.00	26.00	20.00	28.00	26.00	77.84	PLANNING	1.14373
12	CHANDAN	41.00	22.00	21.00	31.00	26.00	78.44	PLANNING	.23380
13	NAVEEN S	30.00	25.00	24.00	24.00	27.00	79.64	TIME	-.87834
14	GANGA RA	54.00	23.00	26.00	27.00	24.00	80.83	PLANNING	1.54815
15	DINESH	38.00	30.00	23.00	25.00	22.00	83.23	COST	-.06951
16	NARESH D	32.00	25.00	24.00	24.00	27.00	86.82	TIME	-.67613

Correlations

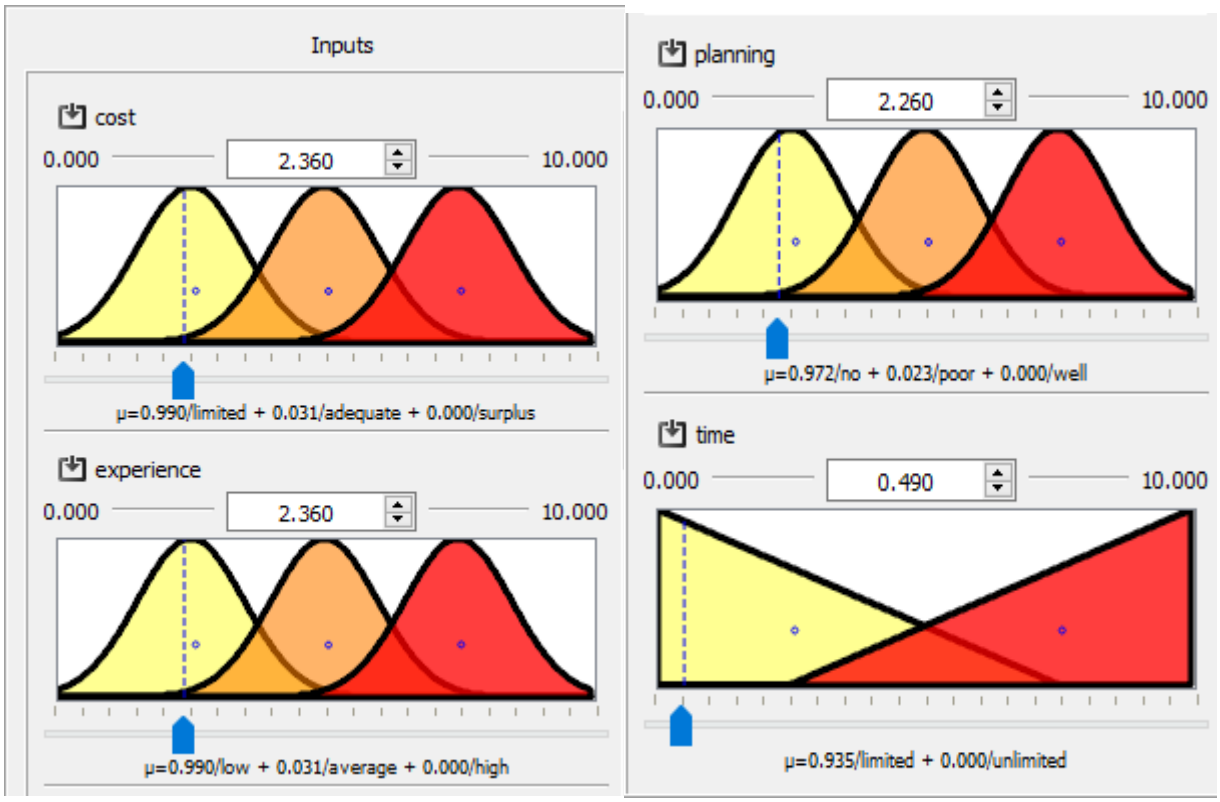
			TIME	EXPERIENCE	COST	PLANNING
Kendall's tau_b	TIME	Correlation Coefficient	1.000	-.369	.095	-.440*
		Sig. (2-tailed)	.	.072	.639	.030
		N	16	16	16	16
	EXPERIENCE	Correlation Coefficient	-.369	1.000	-.239	-.068
		Sig. (2-tailed)	.072	.	.238	.740
		N	16	16	16	16
	COST	Correlation Coefficient	.095	-.239	1.000	-.491*
		Sig. (2-tailed)	.639	.238	.	.015
		N	16	16	16	16
	PLANNING	Correlation Coefficient	-.440*	-.068	-.491*	1.000
		Sig. (2-tailed)	.030	.740	.015	.
		N	16	16	16	16
Spearman's rho	TIME	Correlation Coefficient	1.000	-.424	.032	-.536*
		Sig. (2-tailed)	.	.101	.906	.032
		N	16	16	16	16
	EXPERIENCE	Correlation Coefficient	-.424	1.000	-.247	-.124
		Sig. (2-tailed)	.101	.	.356	.648
		N	16	16	16	16
	COST	Correlation Coefficient	.032	-.247	1.000	-.585*
		Sig. (2-tailed)	.906	.356	.	.017
		N	16	16	16	16
	PLANNING	Correlation Coefficient	-.536*	-.124	-.585*	1.000
		Sig. (2-tailed)	.032	.648	.017	.
		N	16	16	16	16

*. Correlation is significant at the 0.05 level (2-tailed).

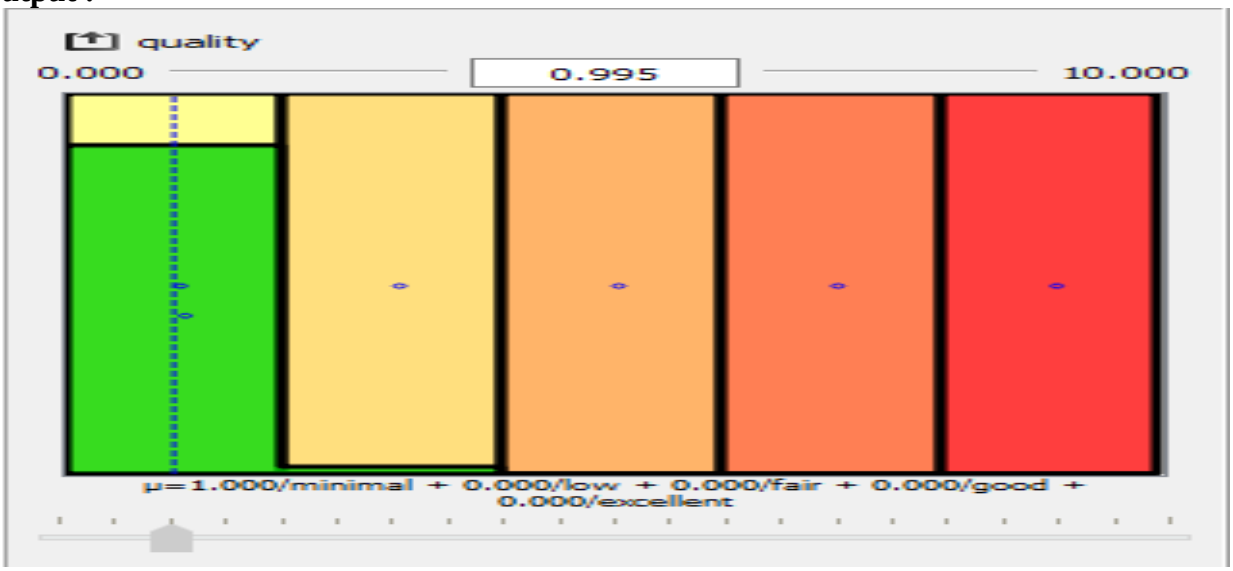
FUZZY LOGIC SIMULATION

Case 1

Cost	Experience	Planning	Time		Quality
low	low	no	restrained		minimal



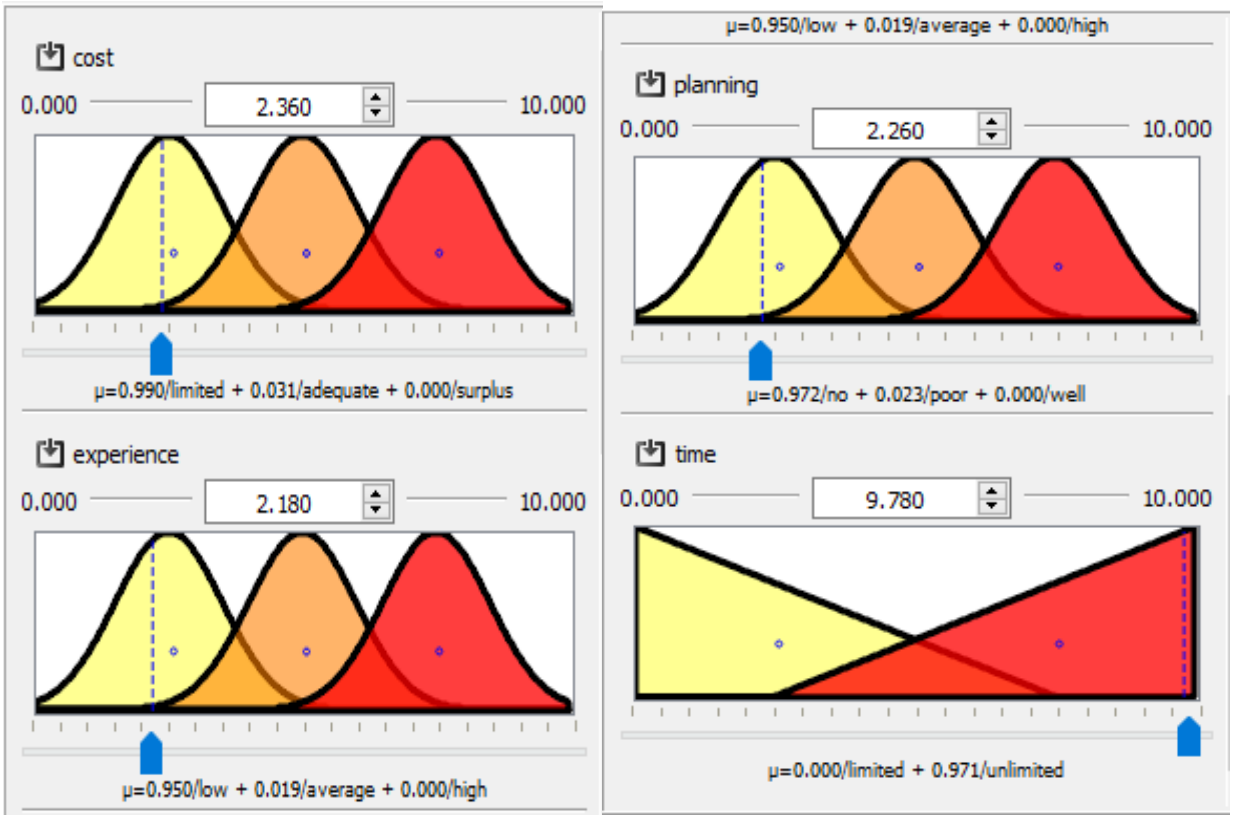
Output :



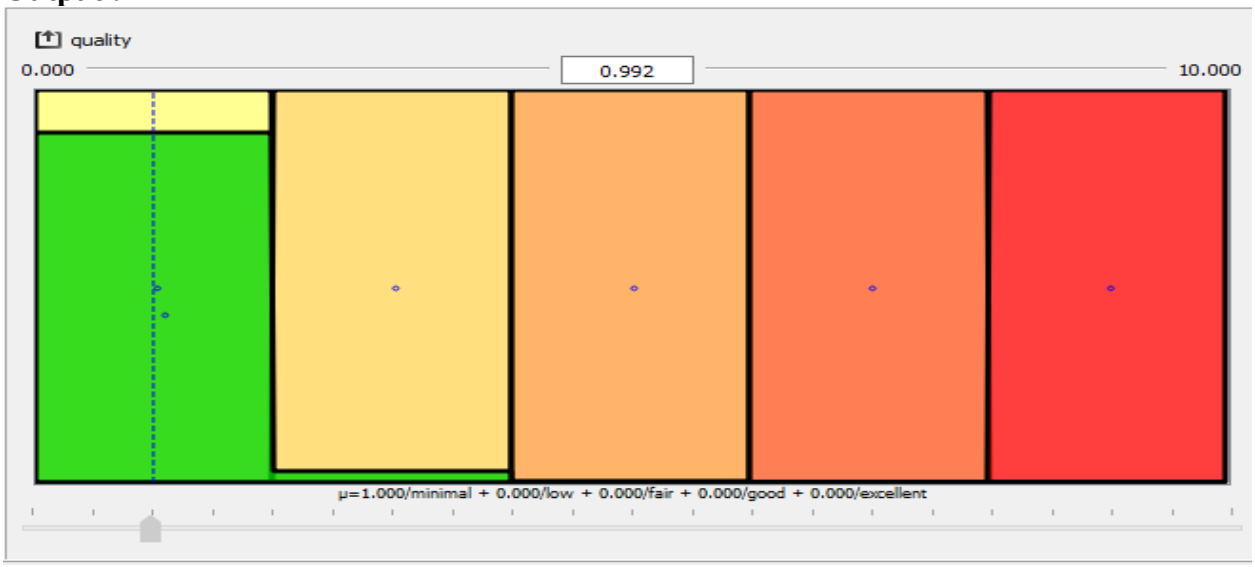
Case 2 :

Cost	Experience	Planning	Time		Quality

Low	Low	No	Unrestricted		Minimal

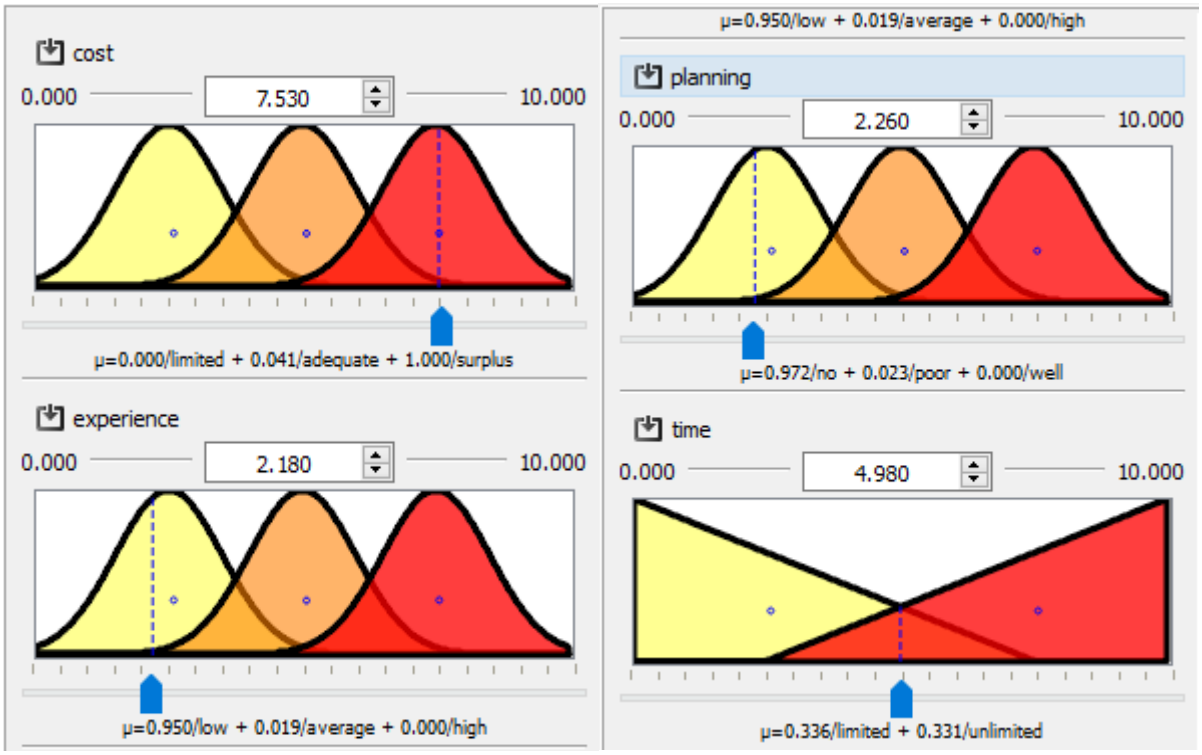


Output :

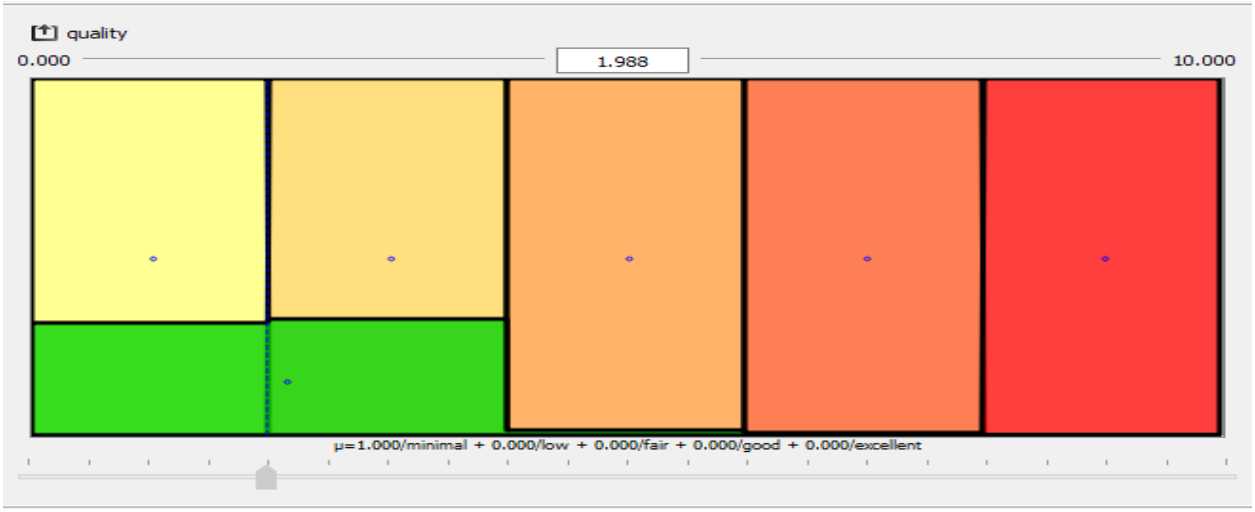


Case 3:

Cost	**Experience**	**Planning**	**Time**		**Quality**
high	Low	No	Restricted		Minimal

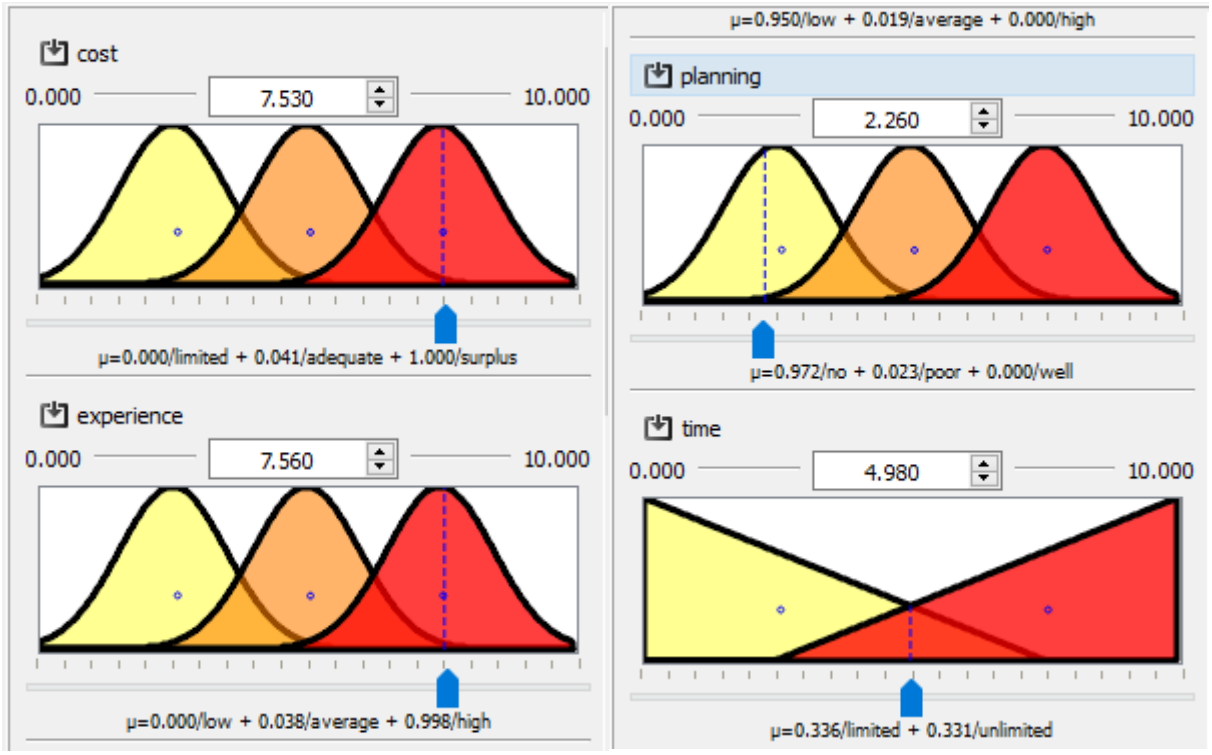


Output: minimal- low quality

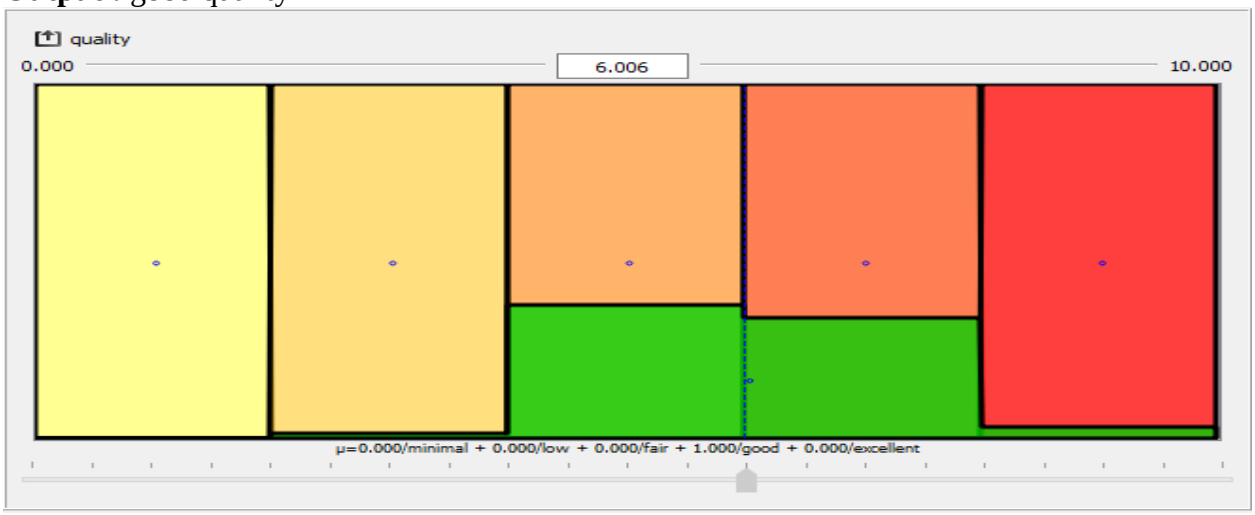


Case 4

Cost	Experience	Planning	Time		Quality
High	High	no	Unrestricted		Fair-good

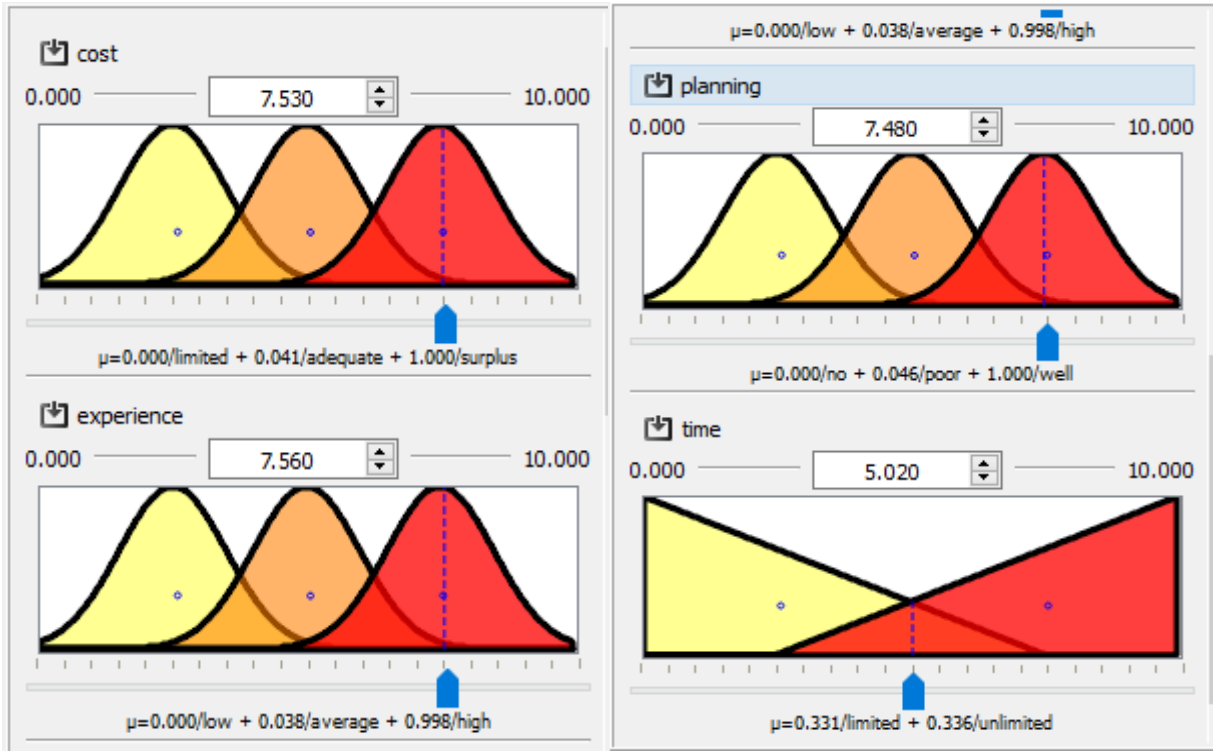


Output : good quality

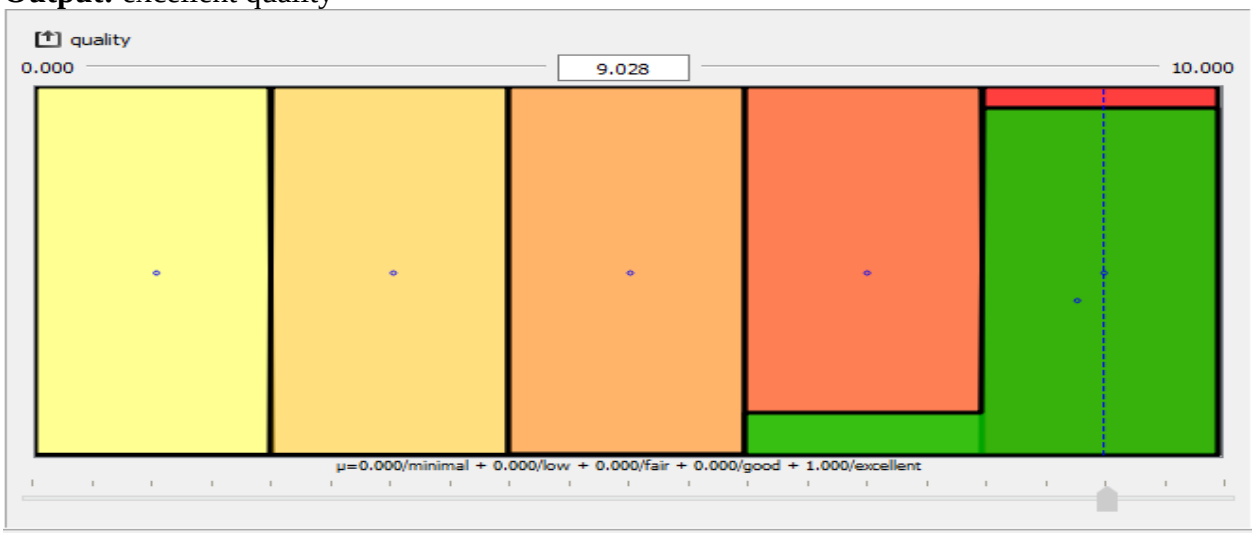


Case 5:

Cost	Experience	Planning	Time		Quality
high	high	well	restricted		excellent

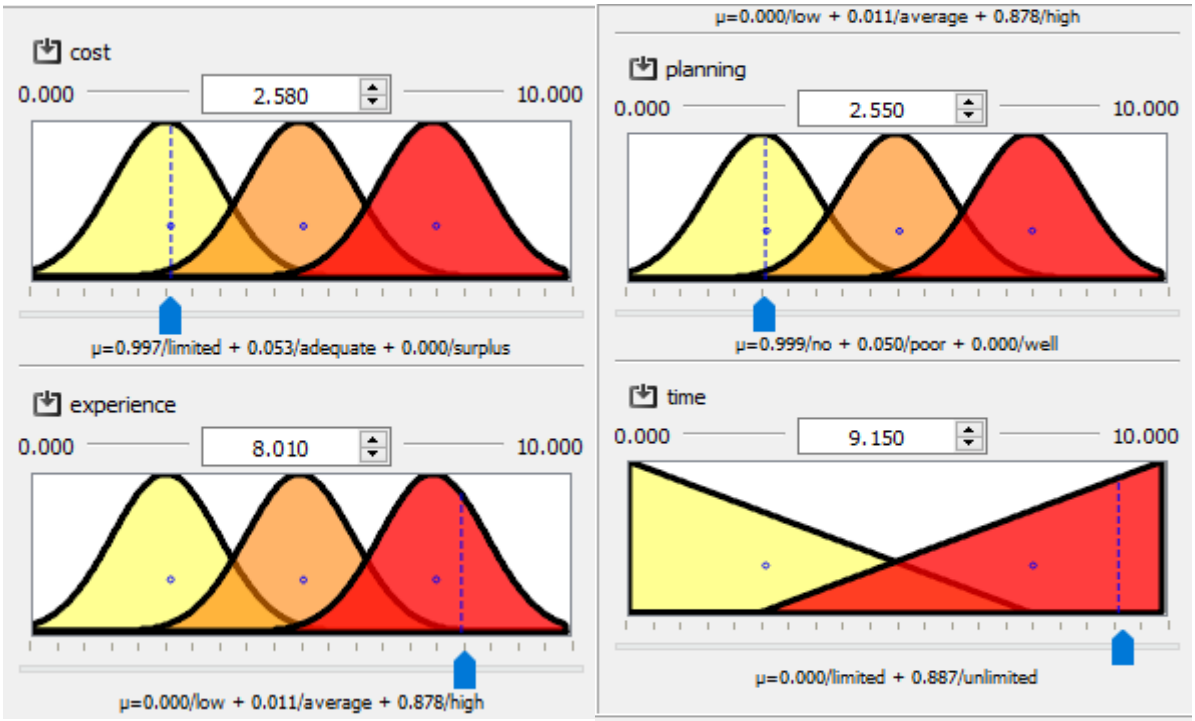


Output: excellent quality

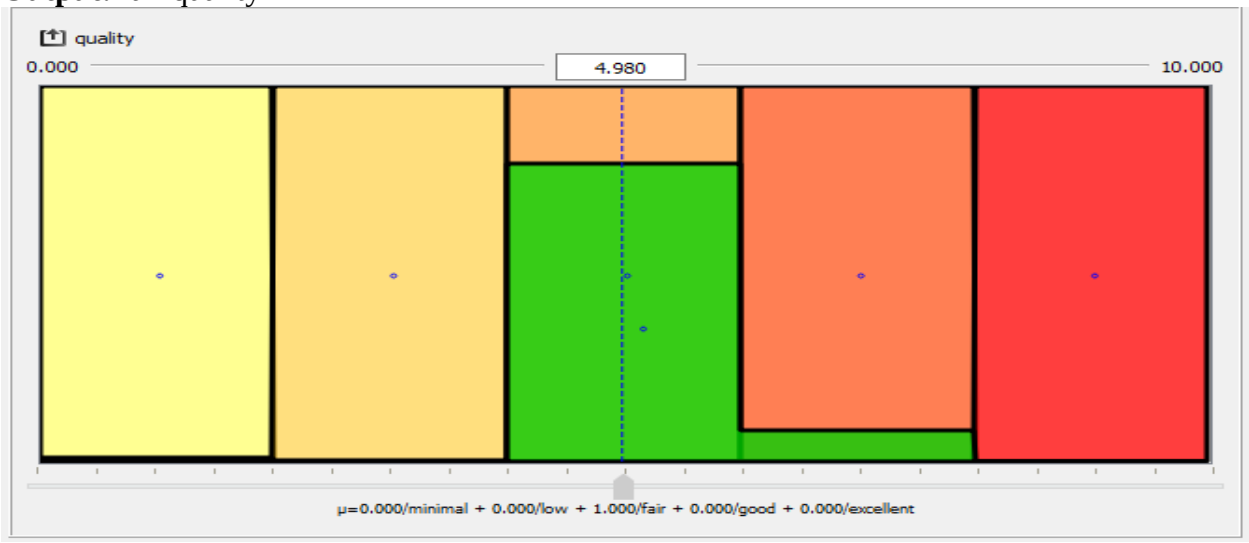


Case 6:

Cost	Experience	Planning	Time		Quality
Low	High	low	unrestricted		Fair-good

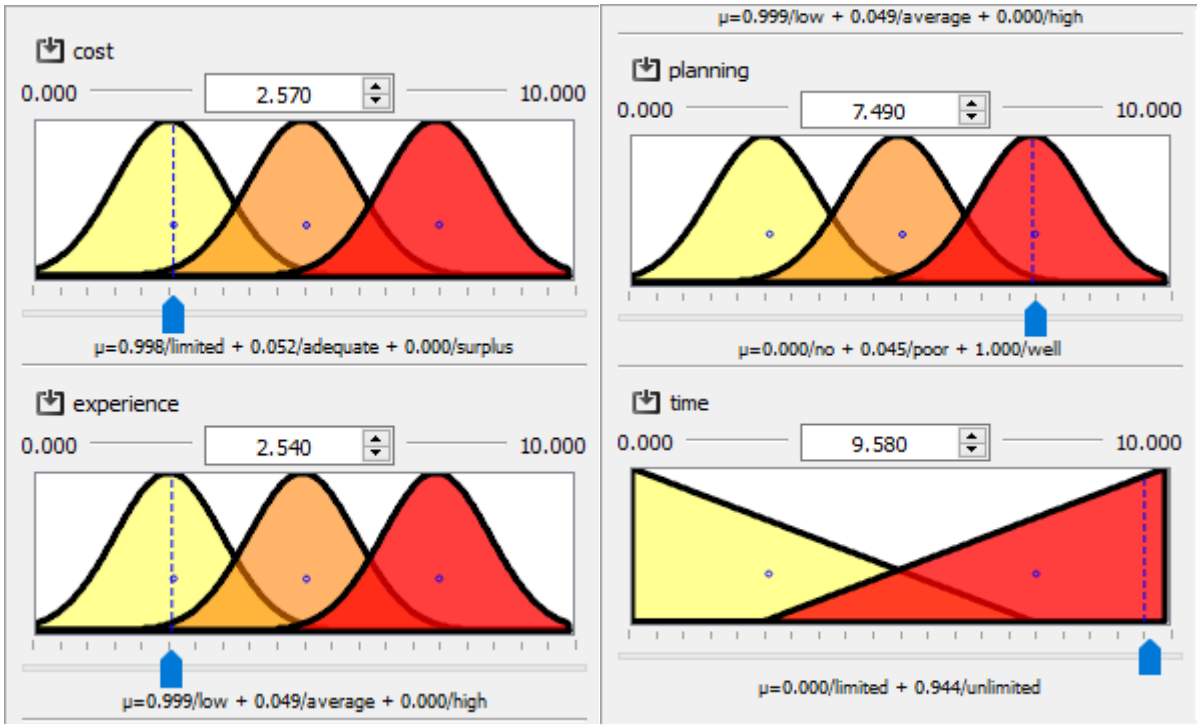


Output: fair quality

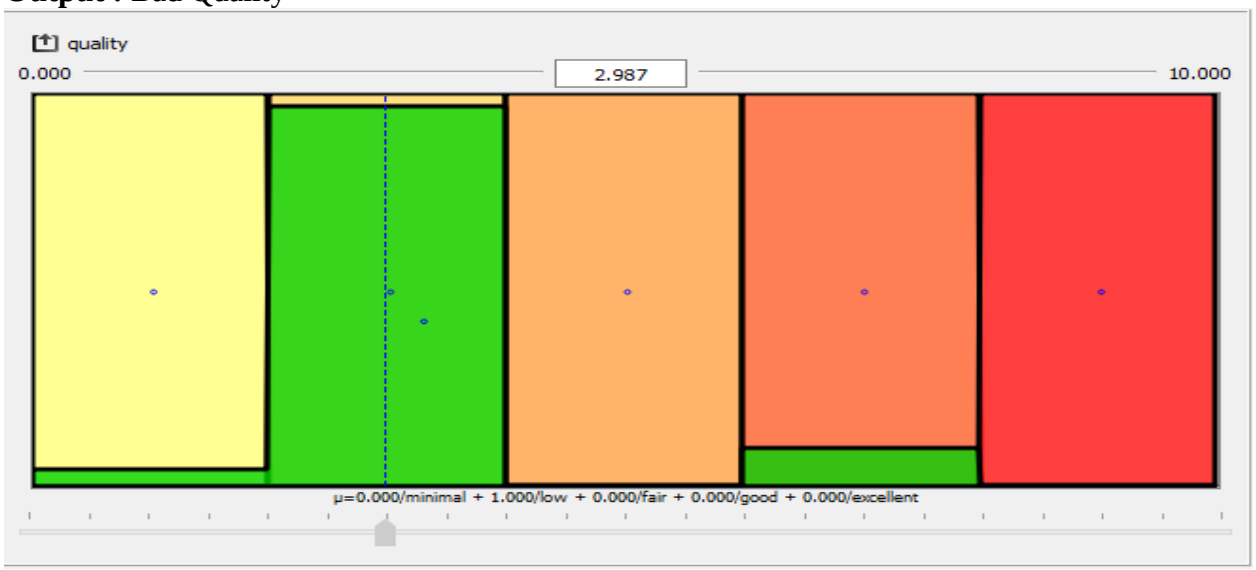


Case 7 :

Cost	Experience	Planning	Time		Quality
low	low	well	unrestricted		Low-fair

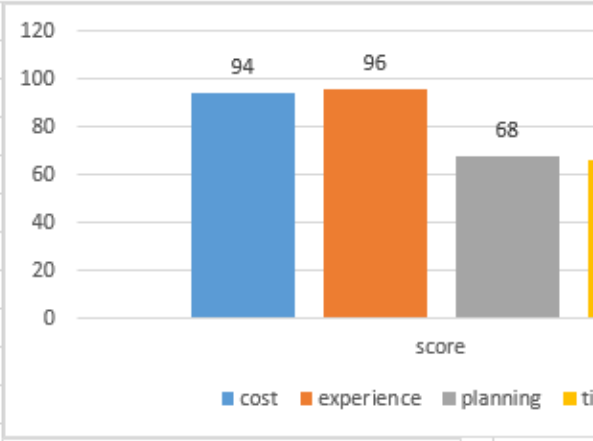


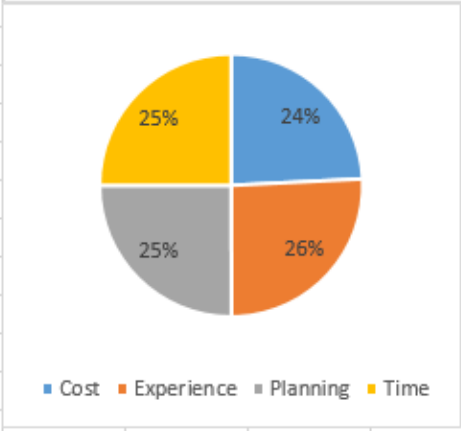
Output : Bad Quality



NAME	MAXIMUM
Specialisation	SAMPLE
Age	SAMPLE

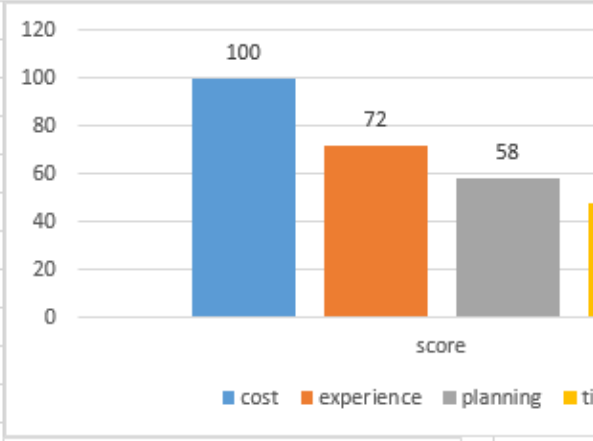
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	8	8	6
ii	8	6	8	8
iii	8	6	8	4
iv	8	4	8	6
v	4	8	6	6
vi	6	8	6	4
vii	2	8	8	6
viii	4	6	8	4
ix	6	6	8	6
x	8	6		8
xi	8	6		8
xii	8	8		
xiii	8	8		
xiv	8	8		
TOTAL	94	96	68	66
SCORE	94	100	97.1428571	97.0588235
	DELTA	97.005988		

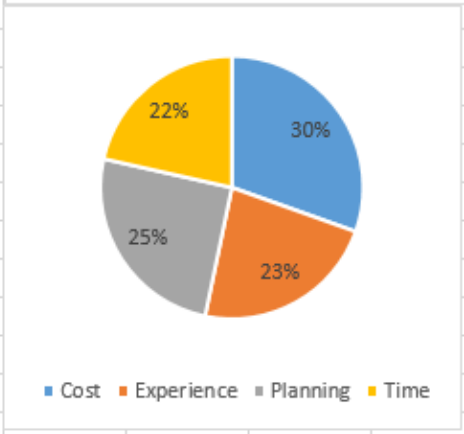




NAME	DINESH
Specialisation	CONTRACTOR
Age	38

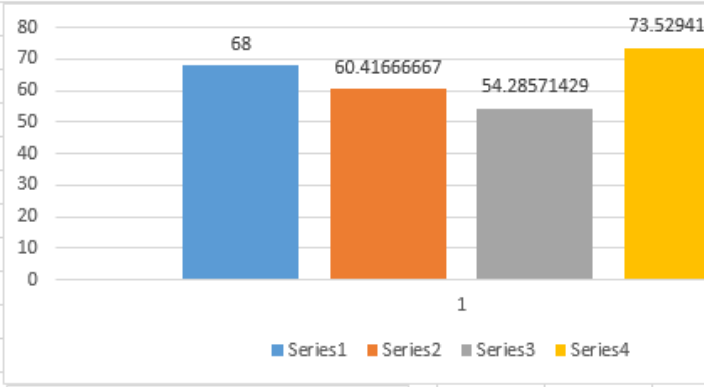
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	6	8	4
ii	8	6	8	4
iii	8	4	2	4
iv	8	4	6	4
v	4	4	8	6
vi	6	6	6	4
vii	6	2	6	2
viii	6	6	8	2
ix	6	6	6	6
x	8	6		6
xi	8	6		6
xii	8	6		
xiii	8	2		
xiv	8	8		
TOTAL	100	72	58	48
SCORE	100	75	82.8571429	70.5882353
	DELTA	83.2335329		

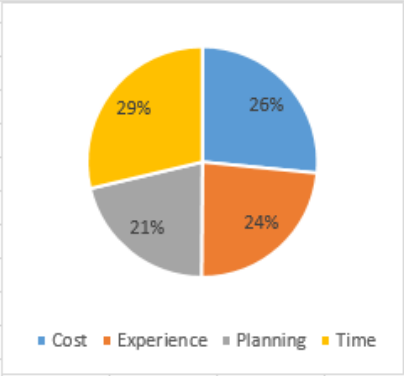




NAME	AVTAR SINGH
Specialisation	CARPENTER
Age	49

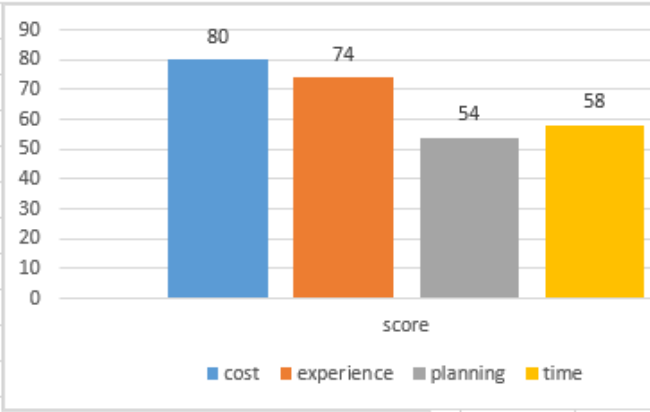
Factor	Cost	Experience	Planning	Time
serial↓				
i	2	4	2	6
ii	6	6	2	4
iii	2	4	2	4
iv	6	4	4	4
v	4	2	0	6
vi	4	4	6	2
vii	2	0	8	4
viii	4	6	6	4
ix	6	6	8	4
x	8	4		6
xi	6	0		6
xii	6	6		
xiii	6	8		
xiv	6	4		
TOTAL	68	58	38	50
SCORE	68	60.4166667	54.2857143	73.5294118
	DELTA	64.0718563		

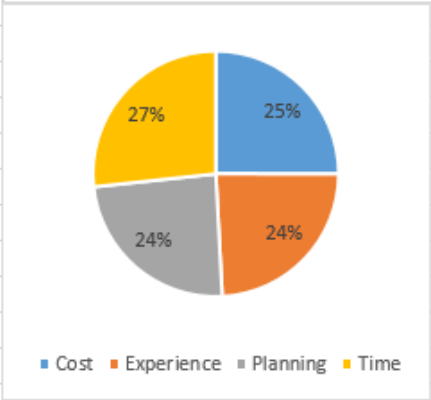




NAME	NAVEEN SAHANI
Specialisation	CONTRACTOR
Age	30

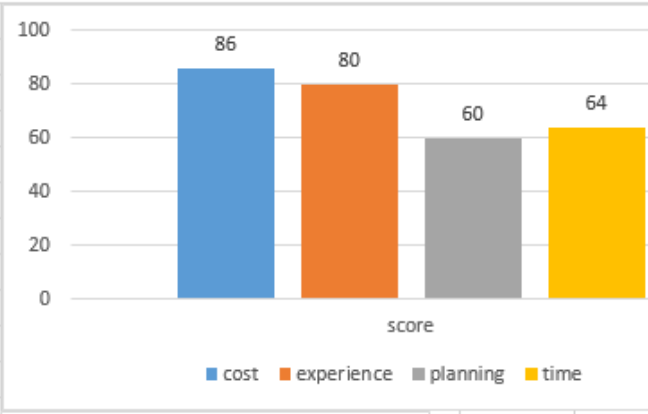
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	6	8	4
ii	8	6	8	4
iii	8	4	2	4
iv	8	4	6	4
v	4	8	6	6
vi	6	4	6	4
vii	2	8	8	6
viii	4	6	6	4
ix	6	6	4	6
x	6	4		8
xi	4	6		8
xii	6	2		
xiii	4	6		
xiv	6	4		
TOTAL	80	74	54	58
SCORE	80	77.0833333	77.1428571	85.2941176
	DELTA	79.6407186		

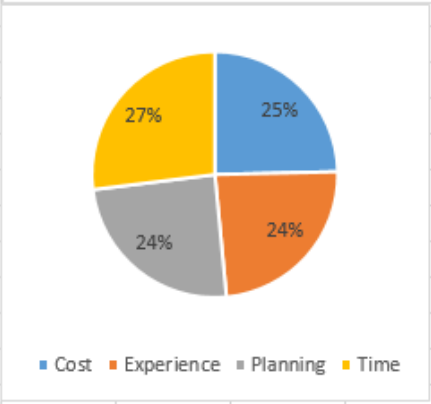




NAME	NARESH DASTA
Specialisation	CONTRACTOR
Age	32

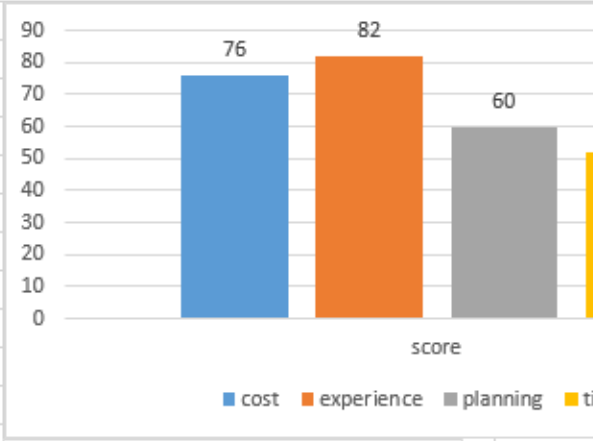
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	8	8	6
ii	8	6	8	8
iii	8	6	8	4
iv	8	4	6	4
v	4	8	6	6
vi	6	4	6	4
vii	2	8	8	6
viii	4	6	6	4
ix	6	6	4	6
x	6	4		8
xi	4	6		8
xii	8	2		
xiii	8	8		
xiv	6	4		
TOTAL	86	80	60	64
SCORE	86	83.3333333	85.7142857	94.1176471
	DELTA	86.8263473		

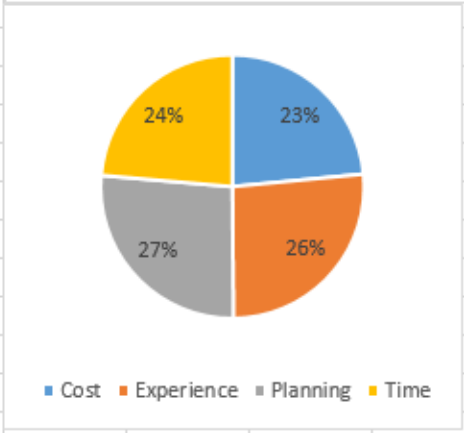




NAME	GANGA RAM
Specialisation	MASON
Age	54

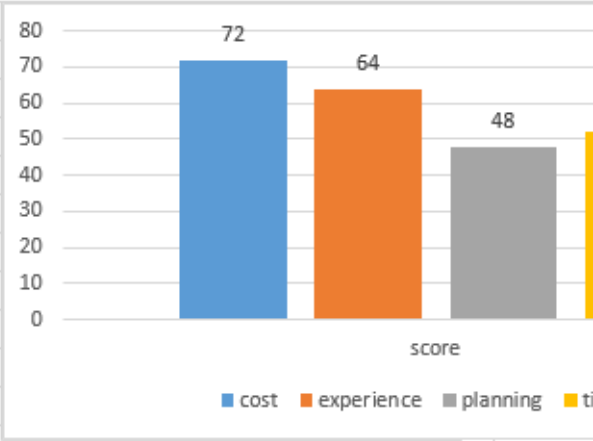
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	6	8	4
ii	8	6	8	4
iii	8	4	2	4
iv	8	4	6	4
v	4	8	6	6
vi	6	8	6	4
vii	2	8	8	6
viii	4	6	8	4
ix	6	6	8	6
x	4	6		6
xi	6	4		4
xii	2	6		
xiii	6	4		
xiv	4	6		
TOTAL	76	82	60	52
SCORE	76	85.4166667	85.7142857	76.4705882
	DELTA	80.8383234		

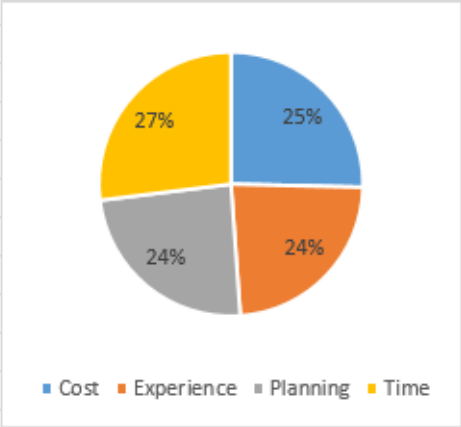




NAME	SUNDER
Specialisation	MASON
Age	50

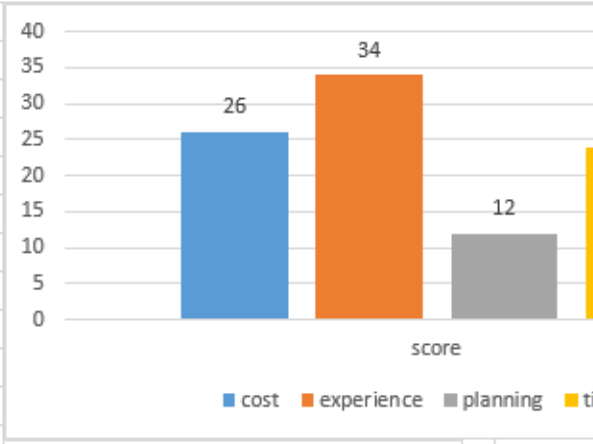
Factor	Cost	Experience	Planning	Time
serial↓				
i	6	4	6	6
ii	6	4	8	4
iii	8	2	6	4
iv	4	4	2	4
v	2	4	8	4
vi	2	2	6	6
vii	4	6	6	6
viii	4	6	6	4
ix	6	6		8
x	6	6		6
xi	6	6		
xii	6	2		
xiii	6	6		
xiv	6	6		
TOTAL	72	64	48	52
SCORE	72	66.6666667	68.5714286	76.4705882
	DELTA	70.6586826		

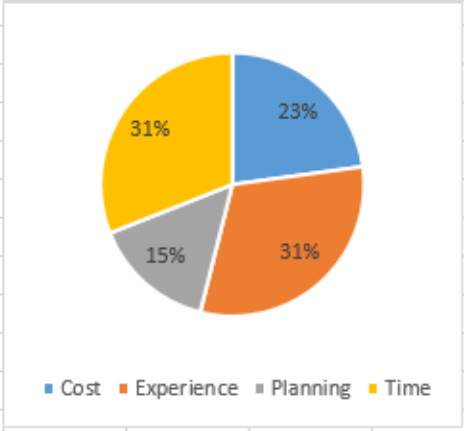




NAME	heera singh
Specialisation	PLUMBER
Age	53

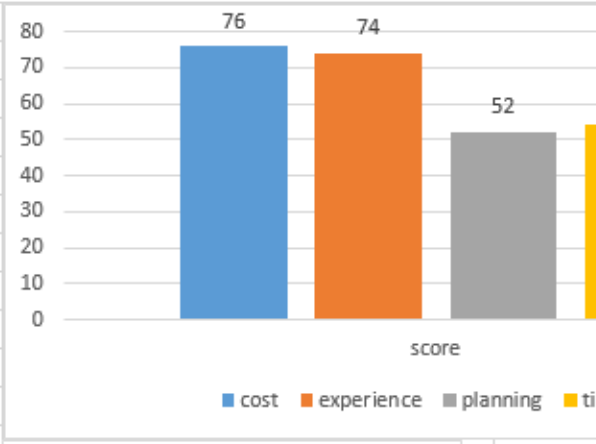
Factor	Cost	Experience	Planning	Time
serial↓				
i	2	2	2	2
ii	0	4	2	0
iii	2	2	0	0
iv	0	0	0	4
v	2	2	0	4
vi	4	0	2	2
vii	2	0	2	4
viii	2	6	2	2
ix	2	6	2	2
x	2	4		2
xi	2	2		2
xii	2	2		
xiii	2	2		
xiv	2	2		
TOTAL	26	34	12	24
SCORE	26	35.4166667	17.1428571	35.2941176
	DELTA	28.742515		

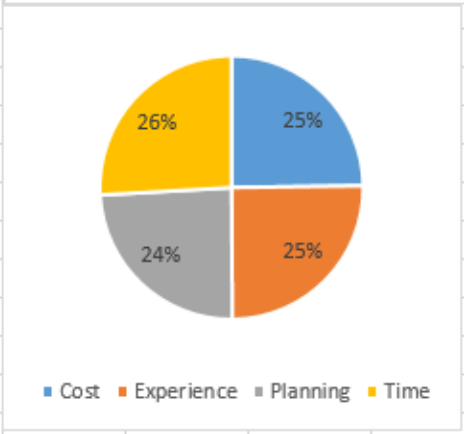




NAME	SOHAN SINGH
Specialisation	CONTRACTOR
Age	50

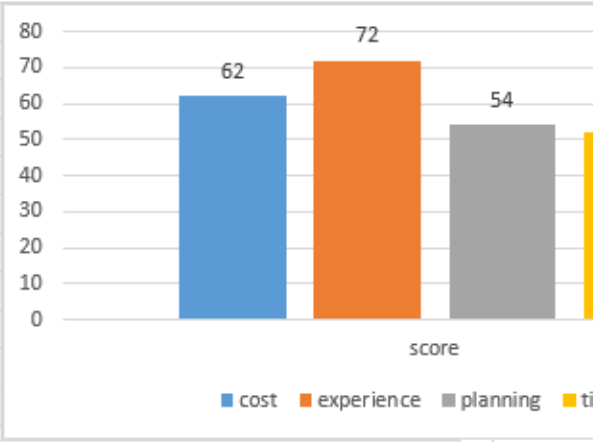
Factor	Cost	Experience	Planning	Time
serial↓				
i	6	4	6	6
ii	6	4	8	6
iii	8	6	6	2
iv	4	4	4	4
v	4	4	6	2
vi	4	4	6	6
vii	2	8	6	6
viii	2	6	6	6
ix	6	6	4	4
x	8	6		6
xi	8	6		6
xii	6	6		
xiii	4	6		
xiv	8	4		
TOTAL	76	74	52	54
SCORE	76	77.0833333	74.2857143	79.4117647
	DELTA	76.6467066		

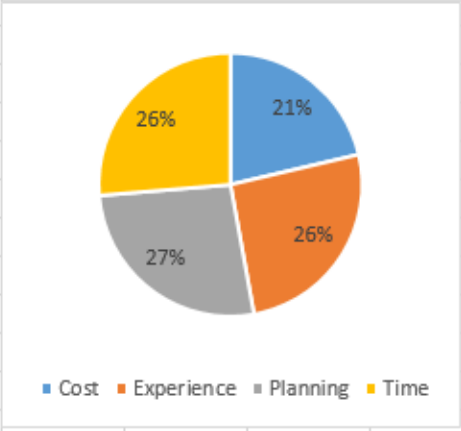




NAME	RAKESH
Specialisation	engineer
Age	22

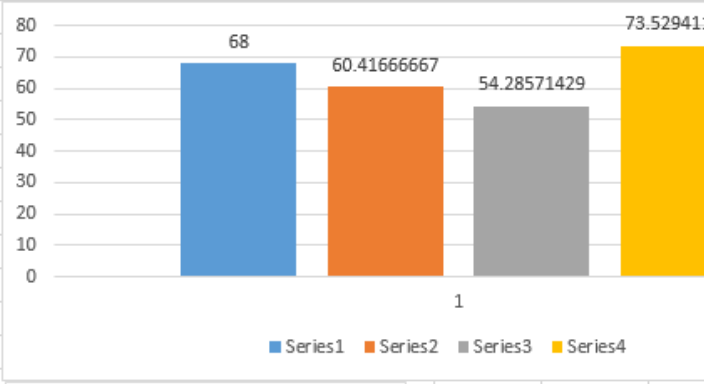
Factor	Cost	Experience	Planning	Time
serial↓				
i	8	2	8	4
ii	8	4	8	2
iii	8	4	4	4
iv	4	4	8	4
v	2	8	6	4
vi	2	8	6	6
vii	6	2	8	4
viii	2	4	2	6
ix	4	6	4	6
x	4	6		6
xi	6	6		6
xii	2	6		
xiii	0	6		
xiv	6	6		
TOTAL	62	72	54	52
SCORE	62	75	77.1428571	76.4705882
	DELTA	71.8562874		





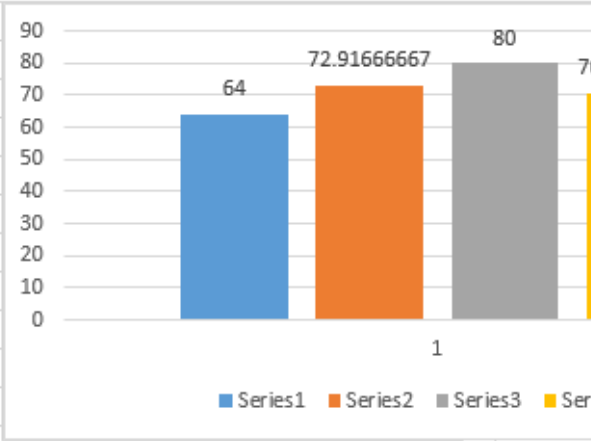
NAME	AVTAR SINGH
Specialisation	CARPENTER
Age	49

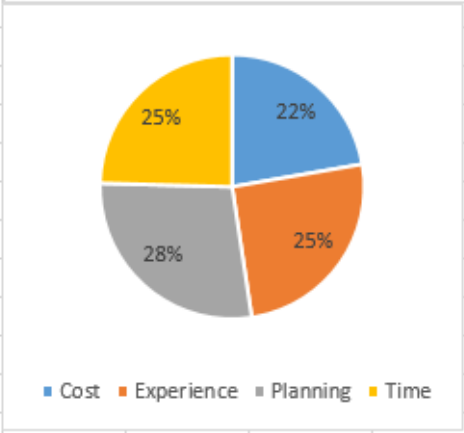
Factor	Cost	Experience	Planning	Time
serial ↓				
i	2	4	2	6
ii	6	6	2	4
iii	2	4	2	4
iv	6	4	4	4
v	4	2	0	6
vi	4	4	6	2
vii	2	0	8	4
viii	4	6	6	4
ix	6	6	8	4
x	8	4		6
xi	6	0		6
xii	6	6		
xiii	6	8		
xiv	6	4		
TOTAL	68	58	38	50
SCORE	68	60.4166667	54.2857143	73.5294118
	DELTA	64.0718563		



NAME	RAJ KUMAR
Specialisation	ELECTRICIAN
Age	35

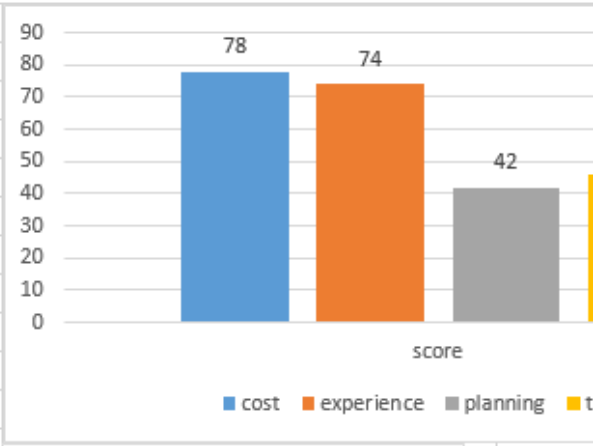
Factor	Cost	Experience	Planning	Time
serial↓				
i	2	6	2	4
ii	2	6	8	8
iii	6	2	6	0
iv	8	4	4	4
v	2	4	8	4
vi	6	4	6	6
vii	4	6	8	2
viii	4	6	8	4
ix	4	6	6	6
x	6	6		6
xi	2	6		4
xii	6	6		
xiii	6	6		
xiv	6	2		
TOTAL	64	70	56	48
SCORE	64	72.9166667	80	70.5882353
	DELTA	71.257485		

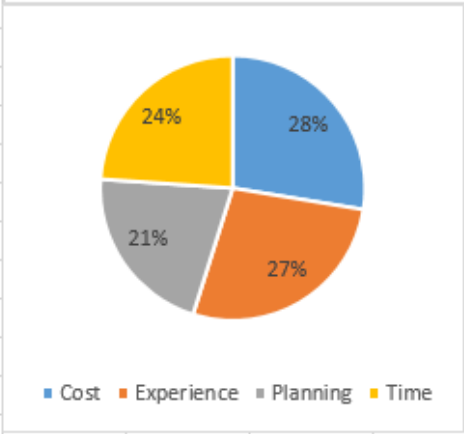




NAME	VINOD KUMAR
Specialisation	MASON
Age	40

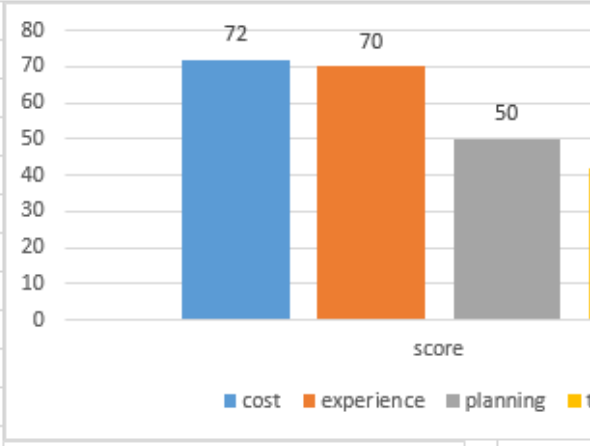
Factor	Cost	Experience	Planning	Time
serial↓				
i	4	4	4	4
ii	4	6	8	6
iii	6	6	4	4
iv	4	4	4	4
v	4	4	0	2
vi	4	4	2	6
vii	6	2	6	2
viii	4	6	8	4
ix	6	6	6	2
x	6	6		6
xi	8	6		6
xii	6	6		
xiii	8	6		
xiv	8	8		
TOTAL	78	74	42	46
SCORE	78	77.0833333	60	67.6470588
	DELTA	71.8562874		

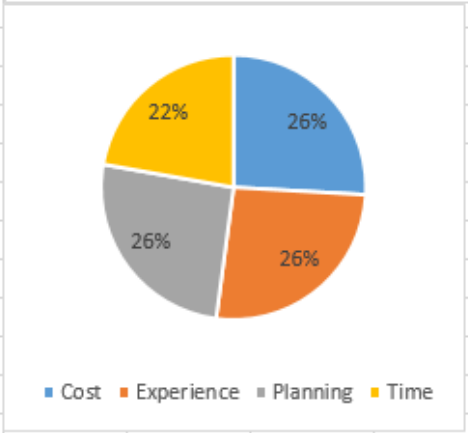




NAME	BALJEET SINGH
Specialisation	ALUMINIUM WORK
Age	30

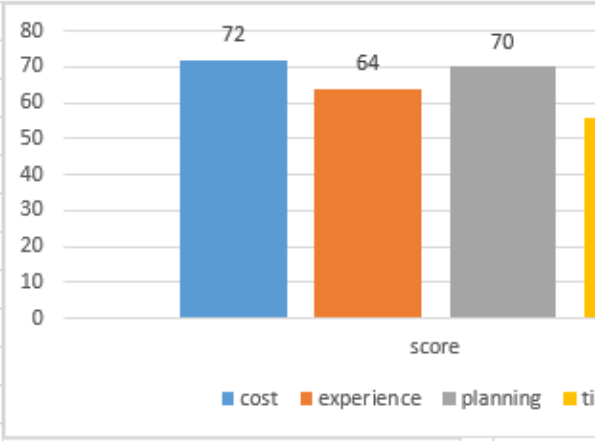
Factor	Cost	Experience	Planning	Time
serial↓				
i	2	4	2	2
ii	4	6	2	6
iii	2	4	6	0
iv	6	0	8	4
v	4	2	6	2
vi	4	8	6	6
vii	6	4	6	2
viii	6	6	8	2
ix	6	6	6	6
x	8	6		6
xi	4	6		6
xii	8	8		
xiii	6	6		
xiv	6	4		
TOTAL	72	70	50	42
SCORE	72	72.9166667	71.4285714	61.7647059
	DELTA	70.0598802		

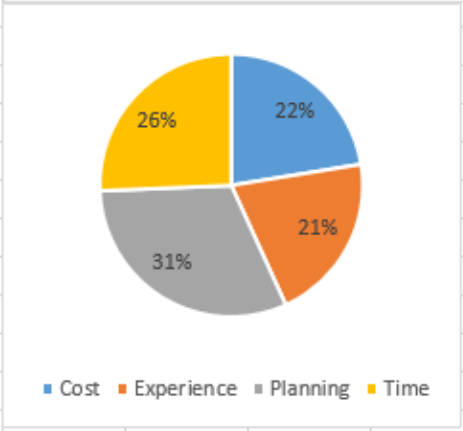




NAME	CHANDAN
Specialisation	CONTRACTOR
Age	41

Factor	Cost	Experience	Planning	Time
serial↓				
i	8	6	8	6
ii	6	4	8	8
iii	8	4	8	4
iv	6	4	8	4
v	2	8	8	4
vi	4	2	6	6
vii	2	6	8	4
viii	4	6	8	4
ix	4	4	8	4
x	6	2		8
xi	8	6		4
xii	4	4		
xiii	4	4		
xiv	6	4		
TOTAL	72	64	70	56
SCORE	72	66.6666667	100	82.3529412
	DELTA	78.4431138		





NAME	DURGESH SINGH
Specialisation	CONTRACTOR
Age	30

Factor	Cost	Experience	Planning	Time
serial↓				
i	8	6	8	4
ii	8	6	8	4
iii	8	4	2	4
iv	8	4	6	4
v	2	8	6	4
vi	2	8	6	6
vii	6	2	8	4
viii	2	4	2	6
ix	4	6	4	6
x	4	6		6
xi	6	4		4
xii	2	6		
xiii	6	4		
xiv	4	6		
TOTAL	70	74	50	52
SCORE	70	77.0833333	71.4285714	76.4705882
	DELTA	73.6526946