A PRACTICAL APPROACH TO CONSTRUCTION INDUSTRY USING BEST VALUE AND SIX SIGMA TECHNIQUES

Submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ENGINEERING

in

CIVIL ENGINEERING

(With specialization in Construction Engineering and Management)

by

Sharvari Mangesh Rath

(Registration Number: Anjuman-26**)**

Under the guidance of

Dr. R. B. Magar

Department of Civil Engineering
School of Engineering and Technology
Anjuman-I-Islam's Kalsekar Technical Campus
New Panvel, Navi Mumbai-410206

2017

A Dissertation Report on

A PRACTICAL APPROACH TO CONSTRUCTION INDUSTRY USING BEST VALUE AND SIX SIGMA TECHNIQUES

Submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ENGINEERING

in

CIVIL ENGINEERING

(With specialization in Construction Engineering and Management)

by

Sharvari Mangesh Rath

(Registration Number: Anjuman-26**)**

Under the guidance of

Dr. R. B. Magar

Department of Civil Engineering

School of Engineering and Technology

Anjuman-I-Islam's Kalsekar Technical Campus

New Panvel, Navi Mumbai-410206

2017

CERTIFICATE

This is to certify that the project entitled **“A Practical approach to construction industry using Best value and Six sigma techniques”** is a bonafide work of **Ms. Sharvari Mangesh Rath (15CEM11)** submitted to the University of Mumbai in partial fulfilment of the requirement for the award of the degree of “Master of Engineering” in “Civil Engineering (With Specialization in Construction Engineering and Management)”

Dr. R. B. Magar	**Dr. Abdul Razak Honnutagi**
(Guide and Head of Department)	(Director, AIKTC)

APPROVAL SHEET

This dissertation report entitled “A Practical approach to construction industry using Best value and Six sigma techniques” by Sharvari Mangesh Rath is approved for the degree of “Civil Engineering with Specialization in Construction Engineering and Management”

Examiners

1. …………………………

2. …………………………

Supervisors:

1. …………………………

2. …………………………

Date:

Place: Panvel

DECLARATION

I declare that this written submission represents my ideas in our own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Sharvari Mangesh Rath
(15CEM11)

Date:

ABSTRACT

The drive to maintain competitiveness by increasing performance has been an ever-present goal of industries within the global market. Although many industries have benefited from classical quality management programs such as total quality management, lean production, and six sigma, the construction industry has remained primarily unaffected. On the basis of the findings, it is proposed that most quality management programs are designed to be instigated by the vendor, by improving the company's ability to deliver a quantifiable, replicable product or service. Despite its highly competitive environment, the construction industry has lagged in its acceptance of quality management programs compared with other industries and even degenerated in performance. Implementation concerns have been eclipsed by much larger points of interest—applicability and value to the contractor or vendor. It is proposed that the current quality management programs have not been correctly translated into the construction industry. As a result, tools designed and proven to increase the quality, efficiency, and stability of a system have become ineffective. This study aims to focus on application of Best Value technique, a quality management program that focuses on improving quality through the elimination of waste that hampers project effectiveness. This technique adopts the methods to reduce client decision making by aligning the most appropriate contractor and vendor to the client through performance information. It successfully transfers risk to the party best fit to address the risk and holding it accountable for the results. An application of this system is studied in venture of selection the best fitted Contractor which directly helps in reduction of waste and delivering a quality product to clients.

Keywords— Best Value Techniques, Contractors, Construction Industry, Six Sigma Techniques, Quality Management Programs

.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATION NOTATION AND NOMENCLATURE

TQM	Total quality management
PBSRG	Performance based studies research group
DPMO	Defects per million Opportunities
BVT	Best value techniques
CSC	Contractor selection criterias
RII	Relative importance index
WAM	Weighted average method
Wi	Relative Weight
WSR	Weight Scale Rating
PSi	Parametric Scale
BV	Best Value

Chapter 1

Introduction

1.1 Quality Management Programs

Quality Management is defined as any approach used to achieve and sustain a high quality output by conforming to requirements and meeting customer satisfaction requirements. Various quality management methods approach an organization through different routes with the same goal in mind—to increase system quality and thereby decrease overall costs. Whereas many industries have used quality management programs as momentum to increase performance and productivity, the construction industry has struggled to do so. Popular programs, including total quality management (TQM), lean production, and six sigma, have been used to harness principles of efficiency to produce dramatically improved results in the manufacturing field. These quality management programs have revolutionized the use of standardized systems, from the assembly of tightly specified products such as automobiles and gadgets, to the execution of commodity services such as information technology (IT) assistance and mail delivery. Although these programs have been adopted successfully by many organizations, significant affect has not been documented in the construction industry.

1.2 Best Value System

The best value system was initially developed at the Performance- Based Studies Research Group (PBSRG) at Arizona State University in 1994. Since its development, the best value system has been tested on more than 801 procurements in $1.8 billion in procured services and $863 million in procured construction. PBSRG has assisted 64 clients in the public and private sectors to apply the best value system, including Entergy, General Dynamics, Schering Plough, United Airlines, Harvard University, Arizona State University, Rochester Public Schools, City of Peoria, Qwest, Idaho Transportation Department, Denver Health Hospital, Canon, Salt River Project, State of Alaska, State of Idaho, State of Missouri, State of Oklahoma, State of Washington, University of Minnesota, University of New Mexico, U.S. Air Force, U.S. Army Medical Command, and the U.S. General Services Administration. Results for the projects include a 98% customer satisfaction rating, with 98% of projects completed on time, 98% completed within budget, and 100% of clients willing to use the best value system on another project (PBSRG 2009; Sullivan et al. 2009).

The average client rated the best value system as 200% more efficient and beneficial than the current process used. The program also has been attributed to decreasing client management by up to 80%. The program began when the research group realized that the low quality experienced universally in the construction arena was attributable to the inefficient system employed in the procurement and execution of the contract and an absence of accountability within the delivery of the project (Sullivan et al. 2009). The poor quality results could not be attributed to or resolved with any one component but were a manifestation of the limitations of the designed system in use. The best value system is an owner-driven program that focuses on improving quality through the elimination of waste by using two primary methods: reducing client decision making by aligning the most appropriate contractor to the client through performance information; and minimizing the need for redundant client management and direction by successfully transferring risk to the party best fit to address the risk and holding it accountable for the results.

1.3 Evaluation of Construction Contractor

The selection of construction contractors are very often conducted during tendering. Tendering definitely gives a client a choice in awarding contract a company which proposes the lowest price and short construction cycles, but usually they do not allow to precisely evaluate a tender. At the same time there are more and more procedures in which the decision criterion of choosing a tender is the price. In recent years, most clients made use of such a method. On the other hand, the research results show that the cheapest tenderers often have problems with completing the project. Accepting the lowest price is the basic cause of the project completion problems because very often lowering the price means lowering the quality. It is true in some cases. The above conditions make that it is especially important to properly evaluate the contactor's capabilities. In an organization's pursuit of continuous improvement, the purchaser (customer) and vendor must be integrated in a quality system that serves the strategic missions of companies. Maintaining data on the continual performance of vendors requires an evaluation scheme. Vendor rating based on established performance measures facilitates this process. There are several advantages in monitoring vendor ratings. Analyzing the historical performance of vendors enables the company to select vendors that deliver good on-time. Rating vendors also helps reduce quality costs by optimizing the cost of material purchased.

1.4 Six Sigma as a Quality Management Technique

Six Sigma, it is a quality management technique that focuses on reducing variation in the process and preventing deficiencies in the product. This technique has been adapted by companies like Motorola, General Electric, Fords, Sun Microsystems etc. This technique is the statistical way to describe how much variation exists in a set of data, a group of items, or a process. Sigma, which stands for standard deviation, is the most useful measure of dispersion. The six sigma principle can be represented on a normally distributed product quality distribution curve. When the mean is located at the center of the normal distribution curve, the lower and upper limits are six times the standard deviation from the center line.

One virtue of Six Sigma is that it translates the messiness of variation into a clear black-or-white measure of success: either a product or service meets customer requirements or it doesn't. Anything that doesn't meet customer requirements is called a 'defect'. Another approach to determining a sigma level is to calculate how many defects occur compared to the number of opportunities there are in the product or service for things to go wrong. The outcome of this calculation is called 'Defects Per Million Opportunities' (DPMO).

1.5 Motivation

Construction industry today, is lacking a proper application of the Quality management techniques. Though several techniques are developed by the researchers, still their practical application, validation and reliability is not properly documented. Contractor selection today is also a biggest challenge today in construction industry. Improper selection may lead to low quality construction, over-budgeting, delay in construction work and so on. Thus, a proper method need to be devise in accordance to improve quality management on site, such that the final output of the project is achieved as required, it is achieved in the stipulated time and the budgeted cost. Thus the definition of quality needs to achieved in the construction industry.

1.6 Aim and Objective of Study

Selecting the most suitable contractor for a construction project is a crucial decision for owners and project managers. Therefore, this study aims at selection of construction project contractors and vendors with recommendations about the suitable criteria for better evaluation of construction bids both technically and financially.

The objectives of this study are as follows:

- Reviewing the various criteria used for contractor's pre-qualification and bid evaluation.
- Identifying the criteria that are actually used to evaluate contractors' pre-qualification and bids in India.
- Introducing some recommendations for enhancing the contractors' selection process.
- Developing a parameter model and assigning weightage to various parameters for effective selection of vendors and contractors.
- Providing Best Value Contractor to a Project and validate the results obtained using another Quality Management Technique.

1.7 Scope of the Proposed Work

In view of the aforementioned problem as specified from the literature review, following scope is outlined for the present investigation.

- The scope of the project is to fix the initial conditions in accordance to predict final project output. This can be achieved by eliminating low bid selection process of various agencies on site and selecting suitable contractor and vendors for the project.
- Setting various selection parameters for a contractor and deciding the ranking based on the weightage calculated for various parameters. Forming weightage and ranking on a model based values.
- Selection of a best value contractor and vendor for the selected site by following a proper methodology and validating the performance of the contractor by six sigma technique.
- Preparing defect measurement sheets for evaluating performance of the contractor and assigning the sigma level to the project contractors and vendors.
- Thus predicting the project completion quality based on the best value technique and six sigma technique.

Chapter 2

Literature Review

2.1 Quality Management Programs in Construction Industry

In the 1980s quality level of the construction industry's performance was alarming, with 37% of all construction reporting major defects (Butt and Clinton 2005). No significant change was evident by the 1990s when the industry was reported to be in "total chaos" and suffering from major constraints (Areola 1997). Murray (1993) commented that this may be attributable to the fact that the industry was impervious to modern change and was structured "as if nothing had changed in the last fifty years." The quality of the industry's performance has not increased significantly in the 21st century, with one source reporting that 29% of projects completed late and 26% were over budget ("Shortages" 2005), and another source reporting that 33% of projects completed over budget and 50% of projects completed late (Georgy et al. 2005). Furthermore, in 2005, the quality of the industry's performance actually appeared to decline, with 72% of industry professionals witnessing a significant increase in the number of change orders occurring for projects in the previous two years. Quality management is defined as any approach used to achieve and sustain a high quality output by conforming to requirements and meeting customer satisfaction requirements (Flynn et al. 1994; Burati et al. 1991). Various quality management methods approach an organization through different routes with the same goal in mind—to increase system quality and thereby decrease overall costs. Whereas many industries have used quality management programs as momentum to increase performance and productivity, the construction industry has struggled to do so. Sullivan (2011) in his study analyzed the three popular quality management programs, namely, TQM, Lean production and six sigma, the basis of their success and failures and their documented level of susceptibility in the construction industry. These program are then contrasted to the best value system, an owner driven quality management program that has been tested recently in construction industry to produce encouraging results.

2.2 Application of Best Value Model in Construction Industry

Best value judgments within the public sector are particularly complicated due to the myriad of interest groups and stakeholders involved in public-sector construction projects (Arlbjorn and Freytag 2012). Park et al. (2014) presented a practical tool for articulating best value criteria during the procurement of public-sector building projects in Korea in their study. They obtained data from sampling 180 stakeholders drawn mainly from a pool of government construction and project management experts in the Republic of Korea. Their study finds that best value judgments are multi-faceted assessments of stakeholder most needs; mitigated by project characteristics; and span functional and aesthetic considerations.

Application of Best value was also studied on the procurement methods. Yu and Wang (2012) in their study contrasted that the Best value procurements are most advantageous over traditional price dominated lowest bid procurements. Many agencies from federal and state levels are adopting best value procurement. Best-value aims at enhancing the long-term performance through selecting the contractor with the offer most advantageous to the owner where price and other selection factors are considered. Factors other than price can vary, but they typically include technical and managerial merit, financial health, and past performance (Gransberg and Ellicott 1997; Gransberg and Senadheera 1999; Gransberg et al. 2006). The inclusion of key factors that match the specific needs of a project increases the possibility of selecting the best contractor for the project. The National Co-operative Highway Research Program (NCHRP) 10-61 research study (Scott et al. 2006) shows an increasing trend in the construction sector toward the use of various best-value procurement methods.

Abdelrahman et al. (2008) in the study presented a model using records of past projects to obtain specific evaluation criteria, from which a best value score is determined for each contractor. The data collected from groups of experts in the Minnesota Dept. of Transportation and two application methods were used to assess the best value, weighted average method and analytic hierarchy process.

Literature on best value shows a need for analysing the past performance of the contractor in similar jobs as an indicator of his/her qualification trend. Elyamany et al. (2010) addresses this issue and proposes a methodology to incorporate quality of delivered product in the BV procurement system of asphalt construction. The research uses past quality control testing results and utilizes Monte Carlo simulation to estimate the probability that the contractor gets full payment as an indication of qualification trend. The QC data were obtained from the Nebraska Department of Roads for a number of Superpave pavement projects. The results show the possibility of assigning a quality score for the contractor based on the past performance. This study contributes to the current practice of best value with a new approach of employing QC as part of the selection process.

Zhang (2006) in the research study explored, Best value Contributing factors (BVCFs) in Public private partnerships (PPPs) through case studies of international PPP practices. This is supplemented by a literature review of the Best value source selection (BVSS) approaches and corresponding BVCFs in the Design-bid-build (DBB), Design-build (DB), and Design-build-operate/maintain (DBO/M) contracts. Also supplemented with interviews and correspondence with worldwide experts/experienced practitioners in diverse public client organizations. The writer has consequently developed a set of 21 BVCFs in PPPs. The relative significance and rankings of these BVCFs have been determined based on a structured questionnaire survey of the opinions of international.

The need to employ the BV arises as construction projects suffer cost and time overruns as well as poor quality and workmanship. These problems are always associated with the low-bid system, which encourages contractors to implement cost-cutting measures instead of quality-enhancing measures. Therefore, it is less likely that the contracts will be awarded to the best-performing contractors who will deliver the highest quality projects (Naval Facilities Engineering Command NAVFAC 1996). State and federal sectors have moved aggressively toward the use of BV procurement, have attempted to measure its relative success, and are convinced that it achieves better results than the low-bid method. At the federal level, the U.S.

Postal Service, the Army, the Navy, the Department of Veterans Affairs, and the Federal Bureau of Prisons have developed procedures and guidelines for source selection contracting applicable to their construction programs (U.S. Postal Service 2005). Various states and local agencies have adopted legislation, in some cases based on the model code, allowing BV concepts to be considered in the selection decision. The American Bar Association's model procurement code provides for BV concepts to be incorporated into the procurement process.

2.3 Contractor Selection in Construction Industry

Contractor selection is a multifaceted decision making process involving the consideration of multiple selection criteria which are mostly subjective in nature and difficult to gauge. Selection of the contractor for the job has long been primarily based on bid price alone (Merna and Smith 1990; Holt et al. 1995). The selection of the lowest bidder is one of the major reasons for project delivery problems as contractors, when faced with a shortage of work, desperately quoted a low bid price simply to, remain in business with the expectation to be offset through claims (Hatush and Skitmore 1997). Recently, there is new substantial literature (Russell et al. 1992; Hatush and Skitmore 1998; Fong and Choi 2000; Wong et al. 2001; Mahdi et al. 2002) which acknowledges the fact that the selection of the contractors for construction projects should be based on a set of multiple decision criteria; both price and non-price related.

To select the most advantageous contractor for the client, many researchers have developed different evaluation methods, such as simple weighting, multicriterion decision making, cluster analysis, fuzzy set theory, analytical hierarchy process (Gale and Swire 2006; Cheng and Li 2004; Lambropoulus 2007). Although most of these methods focused on selection of critical criteria and aggregation method of the evaluation results, none of the research answers advantages of best value over lowest bid procurement. Owners in various sectors have different procedures for evaluating construction bids. The procedure implemented in the public sector for bid evaluating is mostly that of awarding the contract to the lowest bidder (Barrie and Paulson 1992), because clients are publicly accountable and must demonstrate that the best value for their money has been obtained (Merna and Smith 1990).

Araujo et al.(2005) applied a model for contractor selection in the construction industry. Normally, this selection is considering a group decision problem, since various departments are influenced for this choice and its managers participate of the process. Moreover, the study focuses on the situation in which the company wants to select a set of contractors, maximizing the use of resources according with the constraints imposed. In this context, the model utilized considers the interaction between a Group Decision and an Integer Programming methods. Afterward, it was made a numerical application of the model. The criteria used in this simulation were identified from a literature review in papers related to the supplier's selection in the construction industry.

The pre-qualification of construction contractors is the key step in contractor selection for a project. Pre-qualification mainly aims at identifying an array of eligible contractors, which is required for post qualification steps and further considerations. Selection of a qualified contractor could assure the client that the selected contractor is highly likely to be able to achieve the project goals satisfactorily (El-Sawalhi et al., 2007).

Al-Sobiei, Arditi and Polat (2005) in their study presented the way to provide owners with the decision mechanism that will free them from automatically taking the typical transfer of risk to a surety option and also allow them to make intelligent and economical decisions that include retaining or avoiding the risk of contractor default. The study methodology involves using artificial neural network and a genetic algorithm training strategies to predict the default contractors risk.

Singh et al.(2006) attempted to investigate the current situation of the Singapore construction industry. A questionnaire survey was conducted for accruing the data required to identify the important contractor selection criteria and to draw upon construction practitioners opinions regarding the importance of those CSC in assessing the capabilities of the candidate contractors during the selection process. The research reported upon forms part of a larger study that aims to develop a computer-interactive multi-criteria decision system for contractor selection involving identification of CSC for inclusion in the system, investigation of CSC preferences of construction practitioners, and establishment of weights for those CSC from their perceived importance determined through the questionnaire survey of Singapore construction practitioners. The study highlights that there are statistically significant differences in opinions regarding the degree of importance assigned to some CSC among public clients, private clients, and contractors. Findings from the study may act as an aid in improving the Singapore construction industry by helping construction clients identify multiple CSC apart from cost which should always be considered when assessing the capability of candidate contractors during the selection process, by assisting contractors in improving their attributes in line with clients' preferences and by facilitating Singapore construction clients and researchers to develop a contractor selection system capable of assessing multiple attributes of the candidate contractors so that the risk of the project failure due to the selection of an inappropriate contractor is minimized.

The best value system minimizes the complexity involved in all other processes of contractor selection. It aims on selection of contractor by application of filtering process. Best value system aims on two basic process parameters, that is initially selecting the best value contractor for the project through performance information and eliminating construction waste through transfer of risk to the best possible candidate using Risk management plan.

Sullivan (2011) in his study defined the five best filters for selecting a BV Contractor for a project. In the study the first filter is based on the past performance information of the contractor in which contractor is encouraged to survey up to 25 of its best completed projects for its performance in terms of money, schedule, management abilities, professionalism and quality. In Filter 2 the author has given importance to the risk assessment capabilities of the contractor. This includes major risks that can be foreseen for the proposed project, and preparation of a unique plan defining what will be done to minimize the risk if the contractor is awarded the project. Filter 3 is designed as the interview stage which is used to identify the expertise and skills of the contractors. On basis of the initial three filters the best value team, that is the owner team independently rate each interview as below average, average or above average on a number scale, and then compile the score so that the filtered contractors can enter advance filtering stage. Filter 4 compares various selected contractors on the basis of client's need for performance and price. The identified 'Best Value' contractor then is allowed in Filter 5 where the contractor needs to pre-plan the project so that the unforeseen that may affect the project schedule or budget are documented. Thus in the last Filter a risk management plan is devised which ensures risk minimization of the project. If the contractor is unable to complete the pre-planning or if the client's dissatisfaction cannot be resolved in the filtering stage, the partnership is dissolved.

The effective management of materials is closely linked to the successful completion of today's complex construction projects. Excellent performance of material vendors and suppliers is most crucial for the smooth procurement of materials. Bernold et al. (1991) in the study presented a vendor analysis and rating system that could be utilized during vendor evaluation, negotiation of purchase, and actual construction. A vendor-rating approach to secure the best buy in construction was proposed and analysed. In the study the author exclaims that materials are the crucial elements for almost all construction work. The Vendor in this study is analysed on the basis of five categories which are as follows: i. Pre-consideration which measures financial stability of the vendor. ii. Pre-bid performance which includes the responsiveness to the requests for bids. iii. Past project performance. iv. Past post-installation performance. v. Present bid-price. The author has also suggested various parameters on the basis of which rating to the Vendor can be given before awarding any kind of the contract. The rating index was considered for following 15 listed parameters: i. Timeliness of submittal. ii. Lead time for fabrication and delivery. iii. Response time to reject submittals. iv. Cooperation in coordinating with other sub-contractors and vendors. v. Cooperation in contracting engineers for approvals. vi. Cooperation in identifying deviations between product and specification. vii. Responsiveness to problems. viii. Tracking of order. ix. Time reliability. x. Cooperation during installation. xi. Change for expediting. xii. Product quality. xiii. Support during startup procedure. xiv. Production of operating and maintenance manuals. xv. Response to the warranty calls.

2.4 Application of Six Sigma in Construction Industry

According to Pheng and Hui (2004) to examine the strategies and concepts of Six Sigma and to explore if Six Sigma can be applied to the construction industry to achieve the many benefits it has brought to the organizations that have implemented it successfully. A case study on the implementation process of a Six Sigma program by the Housing and Development Board (HDB) of Singapore is presented. An example of how Six Sigma was applied to improve the quality of internal finishes was also presented where improvement measures taken by Contractor A have helped to raise the Sigma from 2.66s to 3.95s. The operational principles that can be derived from this example can equally be applied by other design and/or construction firms.

Sawant and Pataskar (2014) explain that, Six Sigma is a Quality improvement technique that has being implemented in manufacturing and other industries. Six sigma is new to construction industry. This paper describes the basic theory of Six Sigma, principles, methodology and various tools used. A case study of a residential building is taken in which the Six Sigma principles are applied for internal finishing work, the Six Sigma methodology has been adopted to improve the quality and is checked against the sigma level. The findings suggest that proper training and management support and minor changes in current work procedure can help improve the quality and ultimately customer satisfaction which is of prime importance. Desale and Deodhar suggested process improvement methods used in the construction industry and analysis of features and principles of six sigma and there in to review of a project manager, a field and a cost engineers on the same. The interview on Six Sigma is based on quality, performance and management aspects. This study defends and removes any doubt about the positive effects of Six Sigma on construction projects. Particularly, Six Sigma can provide a broader quality concept, detailed performance measurement, and coordination in repetitive process is and performance improvement. It has produced quality improvements directly/indirectly with positive increase in production efficiency.

Han et al. (2008) explains that many researchers and project managers have attempted to improve project performance by applying new philosophies such as lean principle, just-in-time, pull scheduling, and last planner. However, very little research has been conducted on setting definite quantitative goals for performance improvement while considering the defect rate involved in the construction operations. This research explores practical solutions for construction performance improvement by applying the six sigma principle. This principle provides the metrics required to establish performance improvement goals and a methodology for measuring and evaluating improvement.

2.5 Observed Research Gap

From literature survey following research gaps are observed and discussed here as:

- The construction industry mainly focuses on low-price based environment. But the need of the time is to focus on the quality management program which is value-based.
- Though Best Value system was introduced as value-based technique but its major application was observed in procurement. Limited research has been observed in application of best value for best fitted contractor and vendor selection for a particular project.
- The construction industry has witnessed the failure of many contractors due to varying reasons such as poor performance, financial problems, or accidents arising from the lack of adequate safety consideration at worksites. Also the current trend observed in the

construction industry is to focus on the selection of the vendor or contractor on the basis of lowest bid price. All these incidents have led to the impression that the current system of awarding the contracts is inefficient in selecting the contractor capable of meeting the demands and challenges of present times and hence needs to be reviewed accordingly.

- There is less research work carried out for validation of the quality management techniques applied in construction industry.
- Even Six sigma analysis technique is rarely used in construction industry to rate the contractors for the construction work carried out.

Chapter 3

Best Value and Six Sigma Techniques

3.1 Best Value Technique

Best Value Technique (BVT) is a relatively new method developed by Performance based studies research group (PBSRG) at Arizona University. In this approach it is not the price but the quality of the performance that is given importance. Best Value approach is specifically intended to create the highest value: the highest quality at lowest (or least fit in budget) price.

3.1.1 Phases of Best Value Technique

According to Kashiwagi and Byfield (2002) the process of BVT exists of the following four phases.

The key deliverables in this phase include:

- Preparation of the procurement project.
- The selection phase; the supplier is the expert.
- The pre-award phase; the client performs the expert role.
- Execution: the supplier fulfills the expert role.

1. **Preparation Phase:** The first phase is the preparation of the project. The client defines the objectives and the scope of his inquiry. The client formulates the basic core of the question, based on its own internal expertise. The key question is presented objectively and measurable, well adapted to the wider organizational issues, so without stepping into pitfalls, technical requirements or performance indicators.
2. **Selection Phase:** In this phase the client starts with a meeting for contractors where they will concise and concrete their proposals. The client select based on the scope, the risks, and the opportunities and planning.
3. **Pre-award Phase:** This phase is the realization phase where the chosen contractor will deepen the offer with the client. This includes assessing the development of the proposals of the contractor, risk management and reports that are arranged for starting the implementation.
4. **Implementation Phase:** In this phase the contractor reports weekly the progress regarding money, planning and 'undesirable events'.

3.1.2 Measure Performance by Filtration Process

The best value system eliminates owner inefficient decision making and bias by replacing the selection of the contractor with an automated process that aligns the owner with the party that can best fulfill the owner's needs. This is done through the use of five filters as shown in Fig. 3.1 (Sullivan et al. 2009). Each filter provides the client with the performance information that differentiates the competing vendors and expends minimal client and vendor time. Although no filter is perfect in identifying the best value vendor in isolation, the combination of all five filters is intended to ensure that the selected contractor is the best choice for the owner in terms of money, risk, and quality of work.

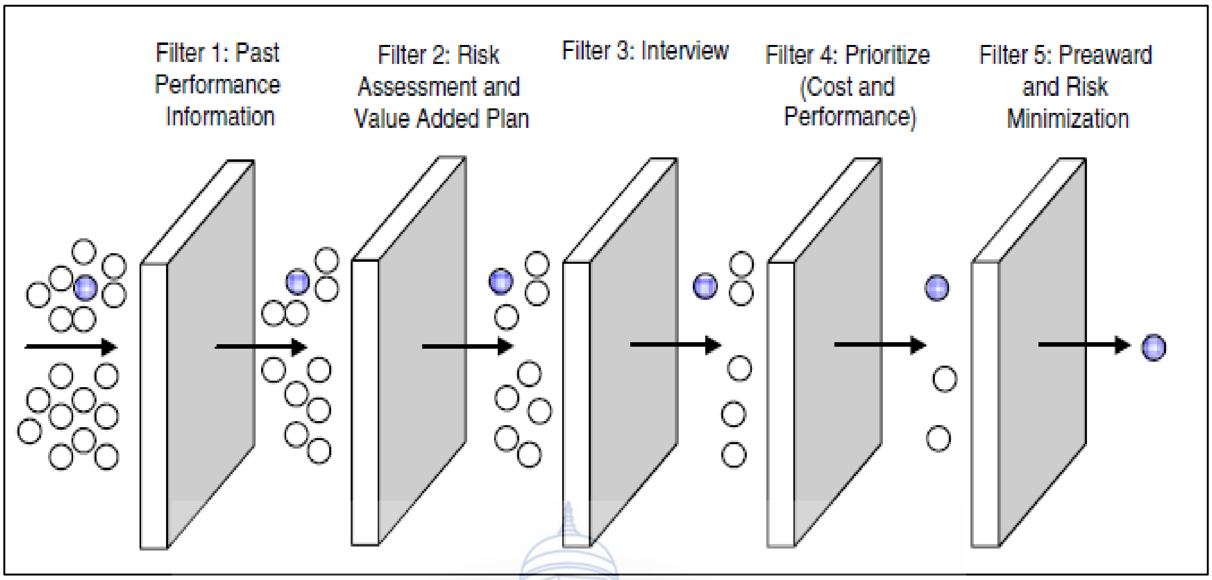

Figure 3.1 Filters of Best Value System

- Filter 1 involves the consideration of each contractor's past performance information. Each contractor is encouraged to survey up to 25 of its "best" completed projects for its performance in terms of money, schedule, management abilities, professionalism, and quality (Sullivan et al. 2009). The primary personnel that the contractor assigned to these completed projects are also surveyed. This reduces client decision making because the client does not have to set the standards for the contractor to match. Rather, each contractor defines the level of performance it is historically willing and capable of generating by the previous customers it has selected to represent its personal standard. The completed projects survey also provides a method to compare the past performance results of multiple competing contractors.
- In Filter 2, each contractor is asked to differentiate itself by composing a brief two to three page risk assessment and value added (RAVA) plan. The plan includes major risks that can be foreseen for the proposed project and a specific, unique plan defining what will be done to minimize the risk if the contractor were awarded the project. The assessment also includes any value added options, which may be beneficial to the owner, that the contractor has devised through its expertise. With this assessment, each contractor can demonstrate its abilities in contrast to the competition and explain what quantifiable benefits would be received from its services. Conversely, the owner is not required to spend large amounts of time identifying the differences among contractors, wading through lengthy marketing propaganda, or filtering information. The owner simply identifies the proposals are below average, average, or above average with a number scale of 1 to 10.

- Filter 3, the interview stage, is then used to identify the expertise and skill of the chief personnel designated by the contractor. In a 20 minute time period, the selected individuals are interviewed separately. The objective is to demonstrate that the interviewee understand and can identify the major project risks before they occur and is comfortable taking responsibility for them. If a contractor is unable to identify risks before they occur, chances are that the contractor will not be able to minimize them once they surface (Zack 2006). Each contractor should also be able to establish that it knows the differences between this project and previous projects in which it has participated. The owner team is then required to independently rate each interview as below average, average, or above average on a number scale, and to compile the scores to reflect the team's perception.
- Filters 4 and 5 are performed relatively close together. In Filter 4, the various contractors are compared on the basis of the client's needs for performance (collected in Filters 1–3) and price. The identified "Best Value" contractor then enters into Filter 5, the pre-award phase, alone. In this phase, the contractor is required to perform the preplanning for the project. This phase is discussed further in the following section. If the contractor is unable to complete the preplanning or if the client's dissatisfaction cannot be resolved in this period, the partnership is dissolved. However, if the contractor is able to complete the preplanning and desires to continue with the project, the contract is then signed.
- Results documented by the Performance-Based Studies Research Group have shown that projects completed under the best value system consistently and significantly reduce the waste found in traditional contracting that results from conflicts between owner and contractor incentives. The best value system allows the emphasis of vendor selection to be placed on quantifiable areas related to the value of the contractor. It places the responsibility of defining quality and identifying differentiation on the expert, the contractor vying for the position. Contractors who are uncomfortable measuring themselves or demonstrating their expertise will perform a natural self-selection and leave the process on their own. This places knowledgeable and skilled contractor at an advantage, and this increases their competitiveness. The system's structure permits the client to identify which contractor best fits its needs and provides the most value for the money, with minimal bias and decision making. If all contractors have similar performance and expertise, the system does not penalize contractors, but still allows them to define performance, with cost the only differentiating factor.

3.1.3 Transfer of Project Responsibility

According to Sullivan (2011) the best value system transfers project responsibility and accountability from the owner to the contractor through three primary methods.

The key deliverables in this method includes:

- The contractor is responsible for defining its contractual responsibilities by identifying risks that are not under its control.
- The contractor is the hub of the project and responsible for documenting and disseminating critical information about unforeseen events that effect the project schedule or budget.
- A method is provided that affects the contractor and holds it accountable for the final project results.

Method I: The first method is addressed in the pre-award period, during the final phase of the contractor selection process. In this period, the contractor is asked to preplan the entire project and to create a risk management plan (RMP) that identifies all project risks that are not under the contractor's direct control. Traditional construction contracting focuses on the technical risk involved in the project (Fig. 3.2). The best value system assumes that the optimally skilled contractor has been hired and has minimal risk performing its expertise. The system takes a supply-chain view of construction and identifies most of project risk in the interaction and cooperation among components—in risks that are not inherently allocated to the contractor. Through the RMP document, the contractor is asked to prepare a plan to control each risk before it happens to minimize or eliminate the risk's potential effect. The RMP becomes a component of the contractor's contract. Instead of the client attempting to define the role of the contractor, the contractor defines what responsibilities are outside of its control and accepts responsibility for all other risks that are foreseeable from the initial contract. Furthermore, to ensure the owner's intervention is devoted to value-added activities, the contractor is required to compose a schedule of the milestones for the entire project during the pre-award period, outlining the client's required actions and decisions throughout the project.

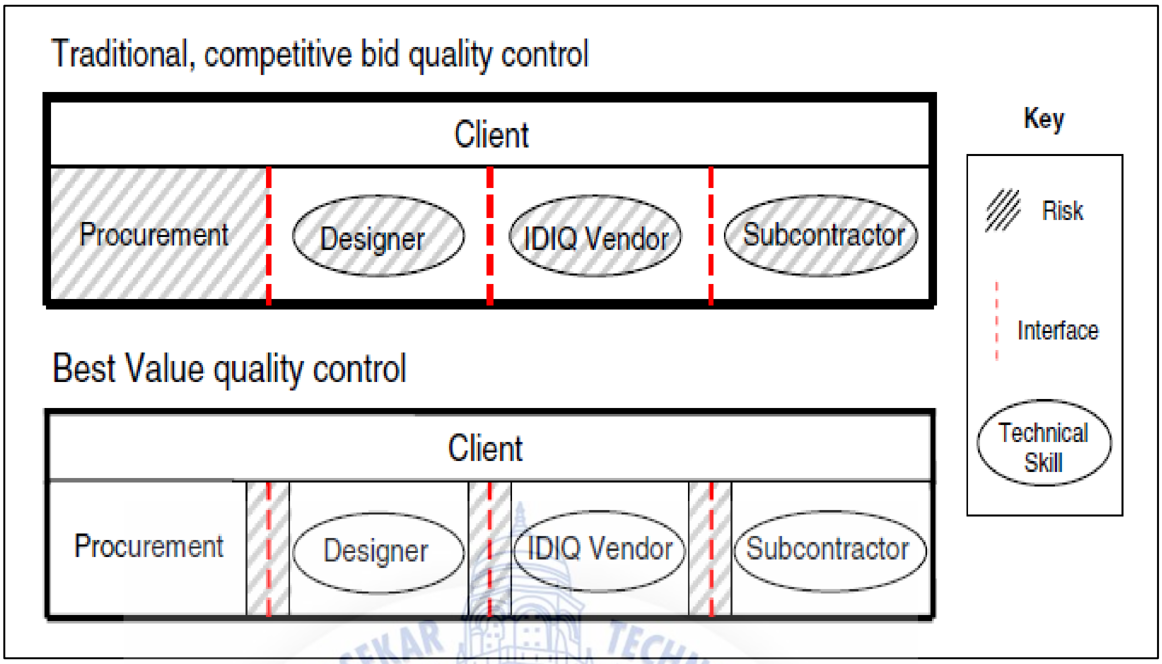

Figure 3.2 Traditional quality control compared to best value quality control

Method II: The second method is included in the contract, but is executed during the construction of the project. The contractor is expected to behave as the expert of the system, directing and watching all components. If there will be a risk to or an effect on the project's schedule or budget, the contractor becomes responsible for documenting and distributing the information as soon as it is identified and for managing the minimization of the risk. This function is facilitated with a tool called the weekly report, a spreadsheet that allows the contractor to record the date a risk is identified, its potential effect on the schedule or budget, why the risk was not foreseen earlier, who is responsible for the risk, what must be done to rectify the risk, and what the contractor is doing to actively minimize the risk. Each week the report is updated and distributed to all parties involved with the project. If a risk is not listed on the weekly report, it is assumed that the contractor is absorbing the time and costs associated with it. The weekly report aligns the contractor's interest with the owner's. The contractor understands that it is at risk for any deviation from the project's original schedule or budget. The only way to mitigate this risk is through the timely documentation of the risk and a proactive response. The report allows the contractor to demonstrate that it has done everything to minimize unforeseen risks that occur during the project. It also allows information that quickly identifies the problem and its source to be shared, allowing the problem to be addressed as early as possible and the participant at fault to be identified.

Method III: The final method is the best value system's ability to hold the contractor accountable for the final project results. This element is built into the system, which is shown in Fig. 3.3 (Sullivan et al. 2010).

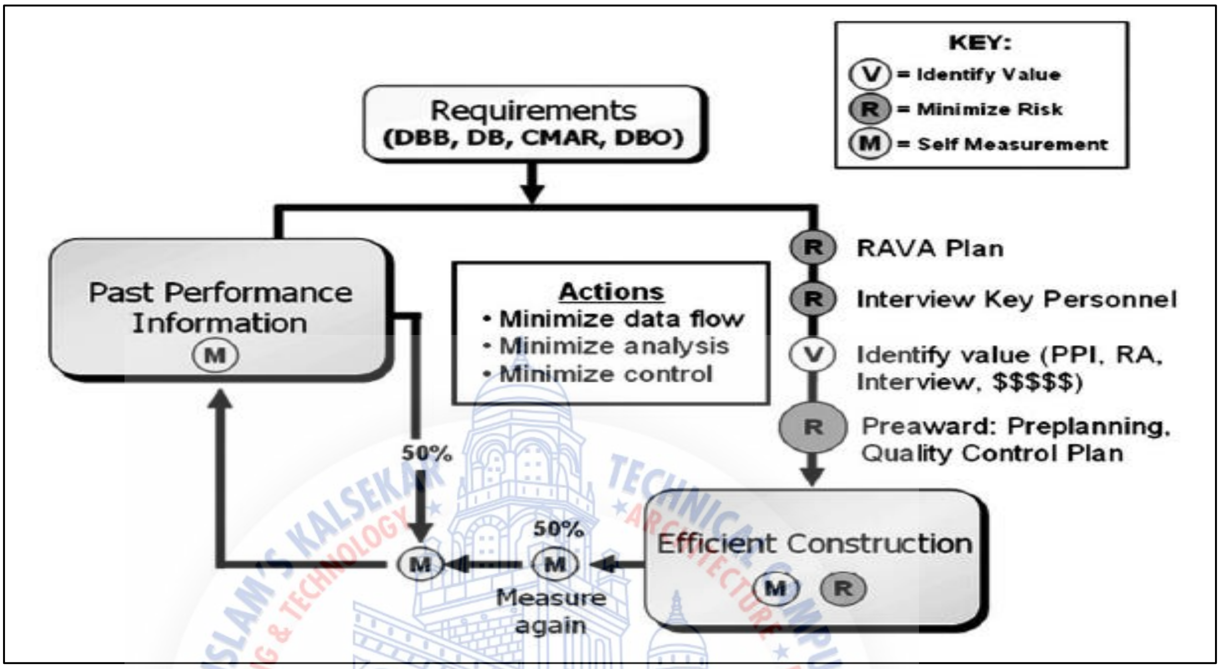

Figure 3.3 System Overview

Once the project has been completed, the client rates the contractor's performance on the project. The questions and ratings are identical to those in the survey used during the selection phase to collect the contractor's past performance information. However, whereas all past projects were averaged and evenly weighted, the owner's rating for the newly completed project becomes 50% of the contractor's past performance information for future projects for which it may compete. This motivates the contractor to view project success and quality as satisfying the needs of the owner, whether they are technical or communicative. The contractor's performance on the best value project will severely affect their competitiveness in future projects bid through the best value system.

3.2 Six Sigma Methodology

Six Sigma is measured in defects per million opportunities (DPMO). Six sigma is an overall business improvement methodology that focuses an organization on

- Understanding and managing customer requirements.
- Aligning key business process to achieve these requirements.

- Utilizing rigorous data analysis to minimize variation in these processes.
- Driving rapid and sustainable improvement in the business process by reducing defects, cycle time, impact to the environment and other undesirable variations.

Process Improvement refers to a strategy of finding solutions to eliminate the root causes of performance problems in processes. Process Improvement efforts seek to fix problems by eliminating the causes of variation in the process while leaving the basic process intact. In Six sigma terms, Process Improvement teams find the critical X's (i.e. causes) that creates the unwanted Y's (i.e defects) produced by the process.

Thus process improvement teams uses DMAIC; a popular six sigma analytic tool. The DMAIC process contains five distinct steps that provide a disciplined approach to improving existing processes and products through the effective integration of project management, problem solving, and statistical tools. Each step has fundamental objectives and a set of key deliverables.

DMAIC stands for the following:

- Define Opportunities
- Measure Performance
- Analyze Opportunities
- Improve Performance
- Control Performance

This tool can be applied at various stages of construction projects. For instance,

1. **Detailed design stage:** To enhance coordination method in order to reduce repetitive work.
2. **Construction stage:** Preparation of builder's workshop drawings and composite drawings, as it needs much coordination among different trades.
3. **Scheduling stage:** Preparation of contractor's construction schedule.
4. **Execution of works:** Executing the contracting work.

3.2.1 Define Opportunities

What is Important?

The objective of this phase is to identify and/or validate the improvement opportunities that will achieve the organization's goals and provide the largest payoff, develop the business process, define critical customer requirements, and prepare to function as an effective project team.

The key deliverables in this phase include:

- Team Character
- Action Plan
- Quick Win Opportunities

1. **Define the problem:** Problem should be based on measurable data and specific.
2. **Identify the customer:** Identification of the customer includes the analyses of problem impacts and a detailed analysis of COPQ (Cost of poor quality).
3. **Identify CTQ characteristics:** Identification of CTQ (Critical to quality) is the determination of the important issues for customers.
4. **Map the process:** A visual representation of the existing process should be prepared in order to look beyond functional activities and core process.
5. **Scoping the project:** Determination of specific project issues, a problem statement and brainstorm session are the purposes of scoping the project.

3.2.2 Measure Performance

How are we doing?

The objective of this phase is to identify critical measures that are necessary to evaluate success or failure, meet critical customer requirements, and begin developing a methodology to effectively collect data to measure process performance. Also to understand the elements of the Six sigma calculation and establish baseline sigma for the processes the team is analyzing.

The key deliverables in this phase include:

- Input, process and output indicators
- Operational definitions
- Data Collection format and plans
- Baseline performance
- Productive team atmosphere

1. **Identify measurement and variation:** Types, sources, causes and detailed impacts of variation on process should be defined by the establishment of measurement.
2. **Determine data type:** Six Sigma team should define data types that will be collected. The main focus is to decide what kind of data and knowledge required for process improvement.
3. **Develop a data collection plan:** Data collection plan provides data collection responsible and data displaying formats.
4. **Perform measurement system analysis:** Graphical and baseline analysis should be performed through MSA (Measurement System Analysis) in order to be sure that data collection plan works accurately and collected data are confidential.
5. **Collect the data:** Collected data should be proper and provide enough information to Six Sigma team in order to determine root causes of the problem.

3.2.3 Analyze Opportunities

***What is Wrong*?**

The objective of this phase is to stratify and analyze the opportunity to identify a specific problem. Also to identify and validate the root causes that the team can thus focus on. To determine true sources of variation and potential failure modes that leads to customer dissatisfaction.

The key deliverables in this phase include:

- Data Analysis
- Validated root causes
- Sources of variation
- Problem statement
- Potential solutions

1. **Perform capability analysis:** Baseline capability should be realized in order to understand performance level of the process.
2. **Select analysis tools:** Six Sigma team should control the graphical analysis and decide which tools will be used in order to find the details of variation and performance.
3. **Apply graphical analysis tools:** A visual performance indications should be realized through graphical analysis techniques.

4. **Identify sources of variation:** Statistical tools are used in order to define the variations sources. The main focus in this step is to find and repair significant variations.

3.2.4 Improve Performance

What needs to be done?

The objective of this phase is to identify, evaluate and select the right improvement solutions. Also to develop a change management approach to assist the organisation in adapting to the changes introduced through solution implementation.

The key deliverables in this phase include:

- Solutions
- Process maps and documentation
- Pilot Result
- Implementation milestones
- Improvement impacts and benefits
- Storyboard
- Change plans

1. **Generate improvement alternatives:** Focus of this step is to define, generate and evaluate the possible improvements.
2. **Create a "should be" process map:** Mapping of best improvement opportunities should be realized by Six Sigma team.
3. **Conduct FMEA (Failure Mode and Effect Analysis):** This analysis is used in order to make the situation analysis of "before the failure".
4. **Perform a cost/benefit analysis:** Cost/Benefit analysis is the comparison between expected benefits and improvements costs.
5. **Conduct a pilot implementation:** The implementation of planned improvements should be conducted on a small scale.
6. **Validate improvement:** Sigma values before and after "Improve Stage" should be compared in order to understand the effect of process improvement.

3.2.5 Control Performance

How do we guarantee performance?

The objective of this phase is to understand the importance of planning and executing against the plan and determine the approach to be taken to ensure achievement of the targeted results. Also to understand how to disseminate lessons learned, identify replication and standardization opportunities/processes and develop related plans.

The key deliverables in this phase include:

- Process control systems
- Standard Operating Procedures
- Training
- Team Evaluation
- Change Implementation plans
- Potential Problem Analysis
- Solution results
- Success stories
- Trained associates
- Replication Opportunities
- Standardization Opportunities

1. **Mistake-proofing:** Remove the error possibilities is the main focus of this step. It is important to remove errors before provoking defects in the process.
2. **Long-term MSA (Measurement System Analysis):** Data collection should be distributed over the long-term in order to measure and monitor inputs/outputs of process improvements through Measurement System Analysis.
3. **Appropriate and applicable charts (statistical process control):** Graphical representation of process should be realized in order to control processes with lower and upper limits.
4. **Reaction plan:** That is a detailed plan of controlling issues and necessary actions if the revised process is no longer under control.
5. **The new or revised SOPs (standard operating procedures):** Six Sigma team should periodically revise the existing documents and procedures in order to reflect improvements results.

Chapter 4

Research Methodology

4.1 Statement of the Problem

Based on literature survey, the following statement of the problem is formulated:

The construction Industry consist variable parameters which needs to be satisfied in according to attain best quality in construction. Thus the final conditions could be predicted if the initial conditions are worked upon. This can be achieved by appropriate contractor selection using Best Value Technique. Also there is very less research for validation of the technique. Hence objective of this study is to practically assign best value contractor for an actual project site and also to measure the performance of the same using six sigma technique. Thus on basis of sigma level obtained; the performance can be evaluated and also the technique could be verified for its further application in construction industry.

4.2 Experimental Programme

The flow of the experimental programme is as mentioned below:

1. To identify the project site for application of the problem statement.
2. Develop the various parameters for selection of the contractor.
3. Grouping of parameters and developing the relation amongst them.
4. Model development for selecting the highest suitable contractor.
5. Application of Best Value technique for filtration of contractor.
6. Selection of Contractor.
7. Application of Six sigma technique on Contractor.

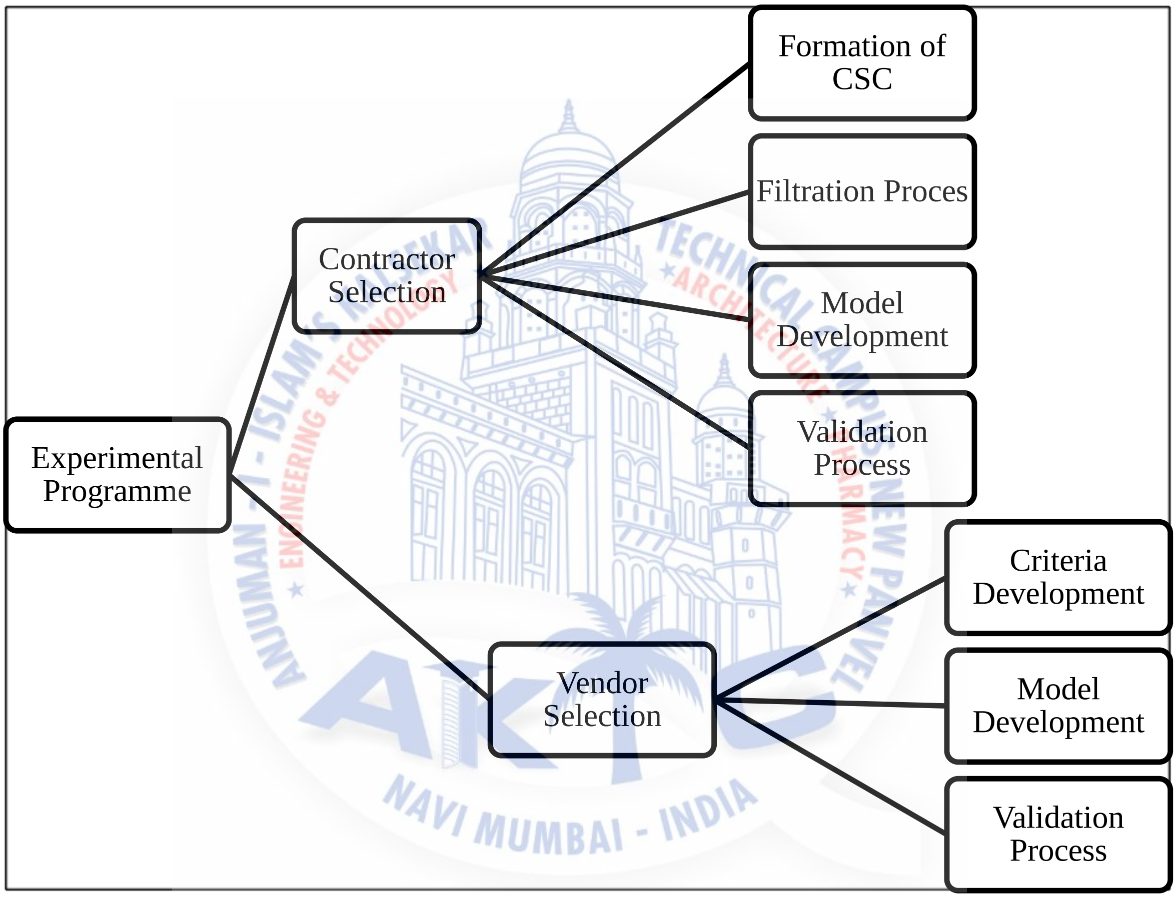

Figure 4.1 Experimental Programme Flow Chart

4.2.1 Development of Contractor Selection Criteria

1. The best value system eliminates owner inefficient decision making and bias by replacing the selection of the contractor with an automated process that aligns the owner with the party that can best fulfil the owner's needs. This is done through the use of filters. These filters are based on the various selection parameters. Each filter provides the client with the performance information that differentiates the competing vendors and expends minimal

client and vendor time. Although no single filter is perfect in identifying the best value vendor in isolation, thus the combination of all filters is intended to ensure that the selected contractor is the best choice for the owner in terms of money, risk, and quality of work.

2. The selection parameters for contractors are generated, henceforth, termed as contractor selection criteria's (CSC). The initial list of 85 CSC was selected based on the review of various literature and project experience of various professionals. In order to identify the representativeness and relevance of the selected CSC; interviews were conducted of various professionals. Around 06 professionals were asked to express their opinion (Yes or No) on whether the selected CSC are relevant in selection context or not. The average working experience of the candidates selected for interview was about 15-18 years.
3. On the basis of the responses received only 41 CSC was selected for filtration purpose of the contractor. These CSC were grouped in following five basic major parameters of filtration as shown in following Table 4.1 (Singh et al. 2006).

Table 4.1 Major Contractor Selection Criterion Group

Group	Criteria	Measurement Capability
I	Contracting company's attribute	These Criteria Measure The Reputation Of The Company, Its Post-Business Attitude, Quality Achievements, Health And Safety Records
II	Past performance information	These criteria assess the level of expertise offered by the contractor.
III	Financial capability of the contracting firm	These decision criteria measure the financial soundness of the contracting company and its ability to meet current liabilities, long-term financial obligations, and to carry current commitments along with the project under consideration.
IV	Performance potential of the contractor	This criteria group evaluates the availability of the resources and experience level of the contracting firm in similar types of project.
V	Project specific criteria	This group assesses the level of technical and management skills of the contracting company in light to the project under consideration.

4. The Contractor Selection Form is thus formed which are then mapped with major Contractor Selection Criteria to get a result about which of the major selection outcomes are satisfied.
5. From Table 4.2, 41 no. of CSC can be observed. The CSC are formulated such that they attain the five major criteria depicted in Table 4.1. Also the questionnaire formed for contractor reviewing process is such that the information regarding selection criteria is collected.

Table 4.2 Contractor Selection Criteria

Sr.no	Major CSC	Particulars
1	Contracting Companies Attributes	Age of Company
2		Familiarity with the regulating Authorities
3		Familiarity with local Working Culture
4		Health & Safety Records of the Company
5		Achievement of the Quality Level
6		Past Failures
7	Past Performance of the Contractor	Type & Scale of the project Completed in last 03 yrs
8		Quality of work in past project
9		Percent of previous work completed on schedule
10		Standards of subcontractor work in past projects
11		Attitude towards correcting faulty works
12		Good relationship with past project owners
13		Relationship with sub-contractors
14		Relationship with suppliers
15		Relationship with regulating Authorities
16	Financial Capabilities	Current Commitments
17		Working Capital
18		Current & Fixed Assets
19		Turnover
20		Profit generating Ability of the Company
21		Capital Structure of the Company
22		Finance Arrangement
23	Performance Potential of the Contractor	Qualification & Experience of Technical Staff
24		Qualification & Experience of Management Staff
25		Depth of Experience on similar type of project
26		Manpower Resources
27		Availability of owned construction plant & Equipment
28		Present Workload & Capability to support the current project
29		Quality Control & Assurance Program
30		Specialized knowledge of particular construction method

31	Project Specific Criteria	Construction Method Statement
32		Proposed project time Schedule
33		Qualification & Experience level of project Manager
34		Qualification & Experience of professional technical Staffs
35		Experience level of project team on similar type of project
36		Number of direct workers available for the project
37		Availability of testing equipment as quality assurance
38		Health & Safety setup for the project
39		Checklist available with Contractor
40		Estimation Softwares Available with the firm
41		Licensed Softwares availability

6. The Contractor Selection Form having set of questions is thus formed which is then mapped with major contractor selection criteria to get a result about which of the major selection outcomes are satisfied.
7. The complete process acts as a part of Filtration process of Best value system.

4.2.2 Relative Importance Index (RII)

1. A survey was conducted to obtained the degree of importance of each defined CSC. The set of CSC was forwarded to builders, engineers of reputed firms. Out of 32 reach-outs around 18 responses were received.

2. In this survey, weight of every CSC was collected from respondent, in terms of '1' as less significant criteria and '5' as extremely significant criteria. On this basis, rank of each CSC was calculated based on the Relative Importance Index (RII) Method as shown in Eq. 1 (Muhwezi et al.2014).

3. These rankings make it possible to cross-compare the relative importance of the factors as perceived from the groups of respondents. All the numerical scores of each of the identified factors were transformed to relative importance indices to determine the relative ranking of the factors. Higher the value of RII, higher the priority of the CSC, thus higher weightage would be assigned to the particular CSC.

$$RII = \frac{\sum^{n} W}{A \times N} \tag{1}$$

where, W = Weight given to each factor by the respondent and will range from 1 to 5 where '1' is less significant CSC and '5' is extremely significant criteria.

A = highest weight given to the criterion, say 5 in this case.

N = Total no. of Responses.

4.2.3 Weighted Average Method (WAM)

Along with RII method, the weightage assignment to CSC would be supported by Weighted Average Method (WAM). In this weight scale equal to 100 and 01 for rating equals to 1 and 5 respectively. The following Eq.2 (Abdelrahman et al. 2008) is used to assign Weight.

$$Weight\ Scale\ \ (WSR) = \left(1 - \frac{rate-1}{5-1}\right) \times 100 \tag{2}$$

The Relative Weight (Wi) is then calculated ranging from 0 to 01, of each parameter to summation of weight for all parameters. The total summation of relative weights must equal to 01.

4.2.4 Best Value Model (BVj)

Based on the CSC, questionnaire was developed for the project site; which was then forwarded to the interested contractors, willing to work for the selected project site. The details of the contractors were collected through forms, which was directly linked to the MS-Excel wherein, weightage and ranking is predefined. The weightage (Wi) to each parameter is given as per defined using RII and WAM Method. As per the inputs received from the contractors, predefined ranking of every input would be assigned to the contractor against the particular CSC which is termed as parametric scale (Psi). The parameter scale (Psi) reflects the value of the performance level of best-value parameter as it exists for a specific contactor and project. The weight (Wi) reflects parameter's importance relative to the other parameters irrespective of any particular contactor or project. The value for Wi is a fixed part of the BVj formula and does not change with the project type or contractor because it represents the relative importance of each parameter to the others. Consequently, project type does not affect this relative importance because it is a generic weight (not project or contractor specific).

Once the parametric Scale and the Weighted Scale is assigned the Best Value for Each Contractor is calculated using Eq . 3 (Elyamany et al. 2010).

$$BVj \ = \ \sum_{i=1}^{n}(PSi) \times (Wi) \qquad (3)$$

where, BVj = Best- Value for Contractor j; n = no. of Parameters included in best value equation; PSi = Parameter i scale; and, Wi = Weight of parameter i.

4.2.5 Contractor Selection

Based on the BVj score obtain, the contractor scoring highest are note down. The complete process until BVj attainment is part of filtration process 01. The high 03 scorer contractors are selected and are allowed to enter Filtration process 02. In second filter the contractor is examined on the basis of information collected in Filtration process 02. The valid, submitted documents of the BVj contractors are verified and accordingly their performance is marked. This stage is hence termed as verification stage, wherein the authentication of the details is verified through uploaded documents. Also the project requirement is verified with the organisation structure, list of equipment/machinery required for project, list of Quality testing equipment available, list and no. of Personal protective equipment available on site and so on. Contractor failing in this criteria are eligible to be replaced or removed from the process. The eligible Contractors then enter the Final filtration stage Filter 03. In this stage, price based environment is given importance. Since the contractors selected through above 02 filters are eligible in Non-price related environment, thus in filter 3, low bidding contractor would be selected and would be awarded the work. In Filter 03, low bid tenders are given high ranking,

4.2.6 Validation using six sigma technique

The next process is to validate the work of the Best Value Contractor using Six Sigma Analysis. The selected contractor filtered from initial three filtration steps is termed as Best Value Contractor. To verify whether the selected contractor performs well, six sigma technique would be applied on his previous similar kind of performance. Defect measurement sheet would be generated in which the observed defects of the project would be marked. The defect also includes the time parameters. This defects would be quantified using six sigma equations and tables. On the observed data collected, Defect per Million Opportunity (DPMO) is calculated using Eq. 4 (Han et al. 2008).

$$DPMO = \frac{(No.of\ Defects\ in\ data\ assessment\ sheet)}{No.of\ Opportunities\ of\ defects \times\ No.of\ Units} \times\ 1{,}000{,}000 \qquad (4)$$

Based on $DPMO$, using sigma conversion as shown in Table 4.3, the sigma level is calculated for the contractor.

Table 4.3 Overview of Sigma Levels & DPMO

Yield	DPMO	Sigma Level
30.9	6,90,000	1
69.2	3,08,000	2
93.3	66,800	3
99.4	6,210	4
99.98	320	5
99.9997	3.4	6

On the Basis of Sigma Level attained by the Contractor, the Best Value Technique for Contractor Selection would be verified. A relationship can be obtain between both the Quality Management Techniques using the Validation process.

Chapter 5

Results and Discussions

5.1 Findings from RII and WAM Model

From 27 responses received the CSC were ranked. On the basis of average rating, Relative Important Index and Weighted Scale for each CSC was calculated. On the basis of RII, Ranking was allotted to CSC and as per Weighted Scale, relative weight was set for each CSC. To develop weightage of major 5 CSC attributes, relationship in RII and WAM was studied, and it was found, both parameters have **0.93** positive correlation. Thus RII Ranks, or WAM parameters can be used successfully for assignment of weights to CSC. Also correlation between Ranks and Relative weight was studied and it was found to be **0.90** negative correlation. Thus it can be stated as Higher the Rank Value of CSC, lower would be the relative weight. The successful distribution of Wi can be studied from Table 5.1. The Major 05 CSC attributes were assigned Weightage and the percentage level attainment was observed which was achieved by contractor Response Questionnaire Form. The results of same are depicted in Table 5.2.

Table 5.1 Assignment of Weight Parameter (Wi) by RII and WAM

Attributes	Particulars	Avg. Rating	WSR	RII	Rank	WAM	Relative Weight	Total Attribute Weight
Contracting Companies Attributes	Age of Company	2.722	3	0.545	36.50	50	0.015	**0.117**
	Familiarity with the regulating Authorities	2.667	3	0.534	38.00	50	0.015	
	Familiarity with local Working Culture	2.556	3	0.512	39.00	50	0.015	
	Health & Safety Records of the Company	3.056	2	0.612	34.00	75	0.022	
	Achievement of the Quality Level	4.389	1	0.878	4.00	100	0.029	
	Past Failures	3.833	2	0.767	25.50	75	0.022	
Past Performance of the Contractor	Type & Scale of the project Completed in last 03 yrs	4.222	1	0.845	10.50	100	0.029	**0.204**
	Quality of work in past project	4.111	1	0.823	15.00	100	0.029	
	Percent of previous work completed on schedule	3.944	2	0.789	23.00	75	0.022	
	Standards of subcontractor work in past projects	4.111	1	0.823	15.00	100	0.029	
	Attitude towards correcting faulty works	2.778	3	0.556	35.00	50	0.015	
	Good relationship with past project owners	2.389	3	0.478	41.00	50	0.015	
	Relationship - sub contractors	3.500	2	0.700	29.50	75	0.022	
	Relationship – suppliers	3.444	2	0.689	31.00	75	0.022	
	Relationship - regulating Authorities	3.333	2	0.667	32.00	75	0.022	
Financial Capabilities	Current Commitments	3.111	2	0.623	33.00	75	0.022	**0.153**
	Working Capital	4.278	1	0.856	7.00	100	0.029	
	Current & Fixed Assets	3.667	2	0.734	28.00	75	0.022	
	Turnover	3.500	2	0.700	29.50	75	0.022	
	Profit generating Ability of the Company	2.500	3	0.500	40.00	50	0.015	
	Capital Structure of the Company	3.944	2	0.789	23.00	75	0.022	
	Finance Arrangement	3.833	2	0.767	25.50	75	0.022	

	Qualification & Experience of Technical Staff	4.222	1	0.845	10.50	100	0.029	
	Qualification & Experience of Management Staff	4.500	1	0.900	3.00	100	0.029	
	Depth of Experience on similar type of project	4.722	1	0.945	1.00	100	0.029	
Performance Potential of the Contractor	Manpower Resources	4.111	1	0.823	15.00	100	0.029	
	Availability of owned construction plant & Equipment	4.000	1	0.800	20.00	100	0.029	**0.234**
	Present Workload & Capability to support the current project	4.278	1	0.856	7.00	100	0.029	
	Quality Control & Assurance Program	4.667	1	0.934	2.00	100	0.029	
	Specialized knowledge of particular construction method	4.333	1	0.867	5.00	100	0.029	
	Construction Method Statement	4.222	1	0.845	10.50	100	0.029	
	Proposed project time Schedule	4.000	1	0.800	20.00	100	0.029	
	Qualification & Experience level of project Manager	3.944	2	0.789	23.00	75	0.022	
	Qualification and Experience of professional technical Staffs	4.000	1	0.800	20.00	100	0.029	
	Experience level of project team on similar type of project	4.056	1	0.812	17.50	100	0.029	
Project Specific Criteria	Number of direct workers available for the project	3.722	2	0.745	27.00	75	0.022	**0.292**
	Availability of testing equipment as quality assurance	4.278	1	0.856	7.00	100	0.029	
	Health & Safety setup for the project	4.056	1	0.812	17.50	100	0.029	
	Checklist available with Contractor	4.222	1	0.845	10.50	100	0.029	
	Estimation Softwares Available with the firm	4.167	1	0.834	13.00	100	0.029	
	Licensed Softwares availability	2.722	3	0.545	36.50	50	0.015	
					Total	**3425**	**1.000**	**1.000**

Table 5.2 Weightage Distribution and % level Attainment of 05 Major CSC Attributes

Attributes	Weightage	Level Attainment	Percentage Level Attainment
I	0.117	6.201	9%
II	0.204	9.588	14%
III	0.153	6.273	9%
IV	0.234	19.422	29%
V	0.292	24.82	37%
Total	**1.000**	**66.304**	**100%**

5.2 Findings from BVj Model

From Contractors Response Sheet Parameter Ranking was assigned against each questionnaire response. This ranking was assigned between '1' and '5'. The most important or suitable for each response was assigned value 5 and the lowest suitable was assigned 1. These scale ranking for each response received from contractor is termed as 'Parametric Scale', and is it pre-defined as per client/owner requirement. The 'Weight Scale' was assigned to each response on the basis on the attribute attained by the questionnaire. The Best Value model was then applied for each response received. Parametric scale and Weight Scale for each response is assigned as per the pre-defined and calculated values. The details of same can be observed in Table 5.3. Detailed assignment of values is depicted in Appendix 02.

Table 5.3 Assignment of Wi and Psi for each responses

Criteria Nos	Weightage Obtained through Mapping	Values for (Psi) x (Wi) based on Contractor Response						
		1	2	3	4	5	6	7
C1	0.27	1.35	1.35	0.27	0.27	1.35	1.35	0.27
C2	0.117	0.351	0.468	0.351	0.351	0.468	0.351	0.234
C3	0.117	0.585	0.585	0.585	0.585	0.585	0.585	0.585
C4	0.387	1.161	1.935	0.387	0.387	0.387	0.387	0.387

C5	0.117	0.351	0.351	0.117	0.351	0.234	0.234	0.234
C6	0.438	0.876	0.876	0.438	0.876	0.438	0.876	0.438
C7	0.555	0.555	0.555	0.555	0	0.555	0	0.555
C8	0.883	4.415	4.415	0.883	0	2.649	0	2.649
C9	0.438	0.438	0.438	0.438	0	0.438	0	0.438
C10	0.555	0.555	0.555	0	0.555	0.555	0	0.555
C11	0.883	0.883	0.883	0	0.883	0.883	0	0.883
C12	0.438	0.438	0.438	0	0.438	0.438	0	0.438
C13	0.555	2.775	2.775	2.775	2.775	2.775	0.555	2.775
C14	0.153	0.153	0.153	0	0.153	0.153	0.153	0.153
C15	0.153	0.765	0.765	0	0.765	0.612	0.765	0.765
C16	0.153	0.765	0.765	0.765	0.612	0.612	0.612	0.612
C17	0.153	0.765	0.765	0	0.765	0.765	0	0.765
C18	0.526	2.63	2.63	2.63	2.63	2.63	0.526	1.052
C19	0.526	2.63	2.63	2.104	2.104	2.63	2.104	2.63
C20	0.292	1.46	1.46	0.292	1.168	1.168	1.46	1.168
C21	0.292	1.46	1.46	1.168	1.46	1.46	1.46	1.46
C22	0.292	1.46	1.46	1.46	1.46	1.46	1.46	1.46
C23	0.292	1.46	1.46	0.876	1.46	1.46	0.292	0.876
C24	0.526	2.63	2.63	2.63	2.63	2.63	1.578	2.63
C25	0.526	2.63	2.63	0.526	2.63	2.63	0.526	2.104
C26	0.526	2.63	2.63	0.526	2.63	2.63	2.63	2.63
C27	0.153	0.612	0.153	0.612	0.153	0.612	0.612	0.153
C28	0.234	0.234	0.234	0	0.234	0.234	0	0.234
C29	0.679	2.716	2.716	0	2.716	0.679	0	2.716
C30	0.234	0.702	1.17	0	0.936	0.468	0	0.702

C31	0.526	2.63	2.63	2.63	2.63	2.63	0.526	2.63
C32	0.292	1.46	1.46	0.876	1.168	0.876	0.584	0.584
C33	0.496	1.488	1.488	0.992	1.488	1.984	1.488	1.984
C34	0.438	1.752	1.314	2.19	0.876	1.314	1.752	1.752
C35	0.643	2.572	3.215	0.643	2.572	3.215	0.643	3.215
C36	0.409	2.045	2.045	0.409	2.045	2.045	0.409	2.045
C37	0.321	1.284	1.284	1.605	1.284	1.284	1.284	1.284
C38	0.321	1.284	0.963	1.284	1.284	0.963	1.605	1.284
C39	0.117	0.117	0.117	0	0	0.117	0	0.117
C40	0.117	0.585	0.585	0	0.585	0.585	0	0.585
C41	0.117	0.585	0.585	0	0.585	0.585	0	0.585
Total (BVj)		**56.237**	**57.021**	**31.017**	**46.494**	**50.186**	**26.807**	**48.616**

The contractor with highest BVj score was evaluated. From Table 5.4 it can be observed that Contractor 1, Contractor 2 and Contractor 5 have high attainment of Best Value Score and thus are eligible for second filtration process. Thus for filter 01 it can be concluded that, Contractor 1,2 and 5 are the most eligible for taking up the project work and handling maximum risk related to time, execution, finance and so on.

Contractors selected from Filter 01, enter filter 02, wherein it is verified that the details submitted by the contractor are as per the project requirement. If any detail or uploaded document found to be false, the contractor can be blacklisted for future projects also. The filtration process can be observed in fig. 5.1. Seven contractors had undergone filtration 01, from the Best value results, 03 contractors were shortlisted and are capable of entering second filter. Advantage of this filter is it minimises the time consuming traditional method of checking all the details of all the contracting firms. It allows checking the details of only selected firms of first filter. Observation from this filter was all the selected contractors had submitted their appropriate details and where eligible to enter the last filter.

Table 5.4 Percentage BVj attainment for each Contractor

Contractor	BVj	Percentage BVj Attained	Remark
1	56.237	**85%**	**Selected**
2	57.021	**86%**	**Selected**
3	31.017	47%	
4	46.494	70%	
5	50.186	**76%**	**Selected**
6	26.807	40%	
7	48.616	73%	

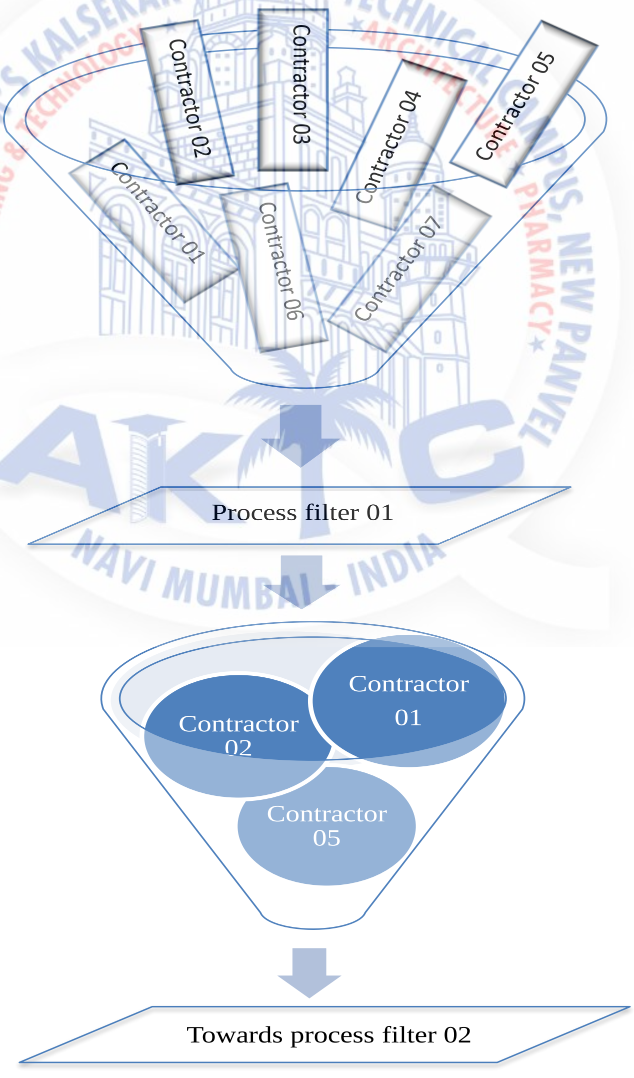

Figure 5.1 Filtration Process

Filter 03 gives ranking to the contractors on the basis of the cost quoted by the contracting firms. In this filter, work estimation and its price value is calculated by client on prior basis itself. On basis of this cost estimation rank 01 to 03 is disturbed among the three contractors, with 01 for higher cost and 03 for lower cost. For quantity estimate excess of 30% is allowed, if the estimation exceeds 30%, '0' value is returned or else '01'. Similar is adopted for cost, if the estimation exceeds 25 %, '0' value is returned or else '01'. The BVj score is then calculated for every i^{th} work estimation by multiplying the return values of cost, quantity and rank assigned. Then the summation of all the values is done to obtain the total BVj score for filter 03. This filter resulted in selection of one 'BVj', that is Best value Contractor, who is apt for the project execution. It can be observed from fig. 5.2 , that the Contractor 05 has scored the least value and contractor 02 has scored the highest value in the price based environment selection. The percentage of Best Value Score attainment for filter 3 can be observed in Table 5.4. The detail scoring is referred in Appendix 03. Thus it can be concluded from the table, that Contractor 02 has the highest attainment of the score

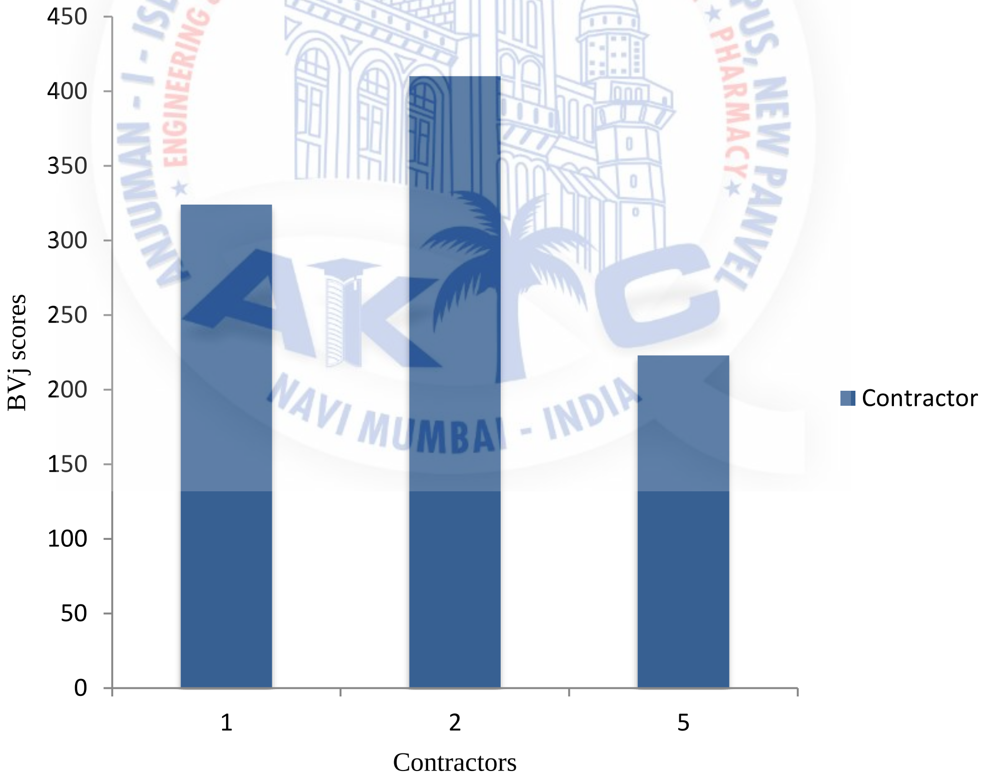

Figure 5.2 Contractors cost based BVj Score obtained from Filter 03

Table 5.5 Percentage BVj attainment for each Contractor through Filter 03

Contractor	BVj	Percentage BVj Attained
1	324	66%
2	410	83%
5	223	45%

5.3 Selection of the Contractor based on score

Applying a percentage value for selection of contractor, we consider 60% weightage of complete non-price based environment and 40% weightage to price based environment. The observation can be summarised as shown in Table 5.6, wherein BVj(v) refers to value based filter results and BVj(p) refers to price based filter results.

Table 5.6 Total BVj attainment by Weightage distribution

Contractor	BVj(v)	BVj(p)	Total BVj Attainment
1	85%	66%	77%
2	86%	83%	85%
5	76%	45%	64%

From fig.5.3 it is observed that Contractor 02 has scored highest in value based environment as well as non price based environment. Even on the basis of weightage distribution **Contractor 02** has scored the highest value. Hence the work could be awarded to Contractor 02.

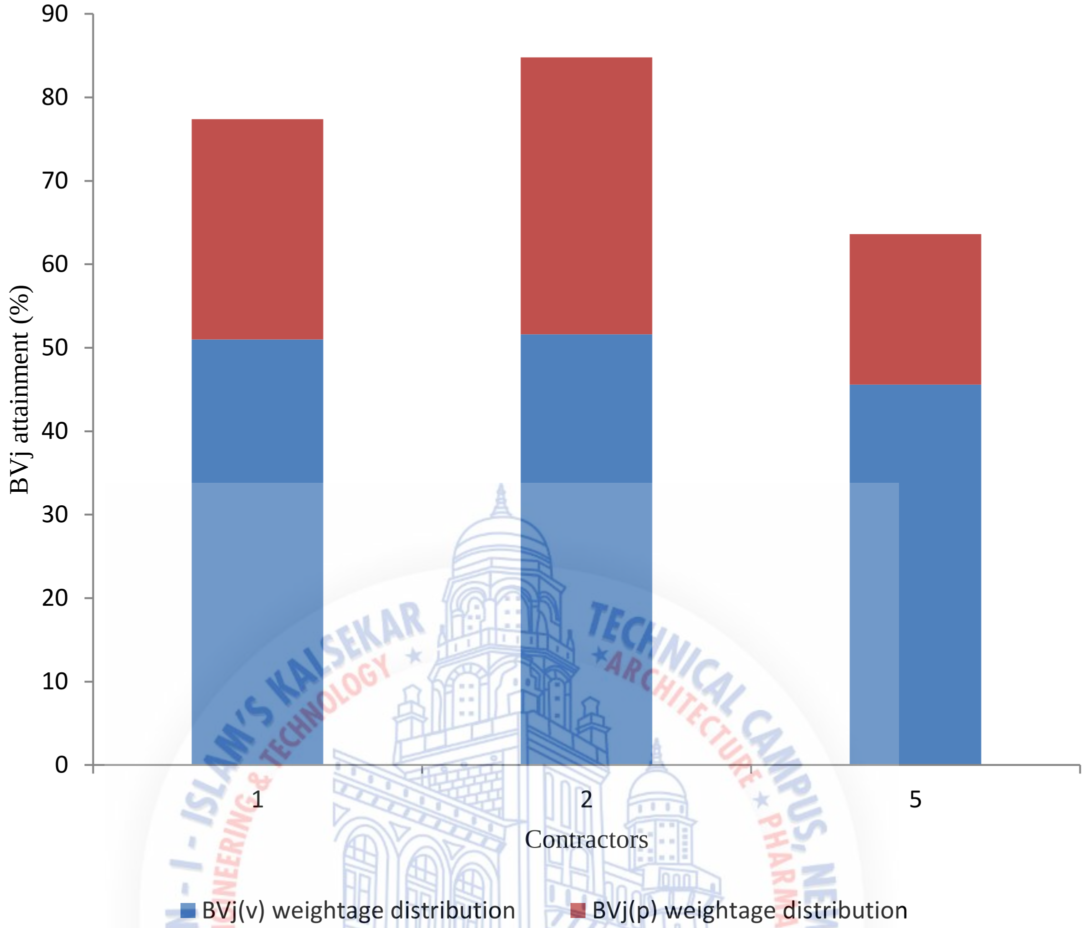

Figure 5.3 Weightage distribution score attainment

5.4 Findings from Six Sigma Model

The work of Contractor 2 was validated. The data assessment sheet as shown in Appendix was prepared wherein data for 12 units were collected. The defect measurement observed were converted into DPMO as shown in Table 5.7. The Sigma Level observed based on DPMO was **3.8.** From the observed validation result it can be observed that yield for contractor is obtained as **98.18%,** which concludes for 1.82% of defects in the complete system. Since this defect calculation also included time delays parameter while assessment, hence it is also observed that the project execution was completed within the stipulated time. Thus Best value contractor is also capable of overcoming project delays.

Table 5.7 Sigma Level Calculation

Sr.no	No. of Units Observed	Defects observed in Assessment Sheet	Opportunities	DPMO	Sigma Level
1	Unit 1	7.00	45	$= 11265.43$	**3.8**
2	Unit 2	12.00	45		
3	Unit 3	6.00	45		
4	Unit 4	3.00	45		
5	Unit 5	6.00	45		
6	Unit 6	4.00	45		
7	Unit 7	2.00	45		
8	Unit 8	9.00	45		
9	Unit 9	4.00	45		
10	Unit 10	9.00	45		
11	Unit 11	5.00	45		
12	Unit 12	6.00	45		
Total	**12**	**73.00**	**540**		

Thus from above table , we can validate the result obtained by best value model. The Contractor 02 selected on basis BVj score also scores high sigma level value. Hence the final conditions could be predicted for the ongoing projects based on the sigma assessment sheets.

Chapter 6

Summary and Conclusions

6.1 Summary

The entire study is about minimising the construction waste that occurs in project execution in terms of time, material, quality, cost etc. This can be brought about by selecting the appropriate key role project executor, that is the contractors and vendors. The research says that low-bid price contractors are given preference for project execution, which often effects project schedule and quality. Thus this study eliminates the construction waste by focusing on choosing appropriate contractors by best value model, so that the project execution can be carried out appropriately considering effective and economic construction. Also this study is accompanied with the validation of the best value technique by using Six Sigma Analysis. Thus, using Six Sigma analysis sigma level of the selected contractor could be predicted, and on basis of this prediction the eligibility of the contractor for the future projects could be identified. On basis of these techniques, through complete analysis, a best value contractor was selected and based on the sigma level, conclusion of the research work was made.

6.2 Conclusion of the experimental program

The best value model can be used to predict the suitable contractor for the execution work. Contractors are the link with the various agencies involved in the project and also the key responsible factor to carry out project execution on time in accordance to the quality. Hence choosing Best value contractor, it helps eliminating construction waste. In this study it is observed that applying filters in contractor selection helps to define the project specific characteristics at the initial phase of construction itself, which enables the client/owner of the project to transfer the maximum risk to the party which best suits to handle it. Even through filters financial risk also are taken into account. So using the Best value Model, Contractor is given direction to focus on the non-price related environment which is equally important as that of price based environment. Thus it can be concluded that controlling initial phase of any construction activity, could lead in prediction of the final phases.

The usage of RII and WAM models helps finding the weightage of various parameters that can be used in contractor selection process. On basis of these models it is easy to classify the highest weighing attributes. Even from correlation factor it could be judged that both the models are highly correlated with each other and thus for future studies any one model could be choose for its application in weightage calculations. The application of Filter 02, helps in verifying the selection of candidate. It helps in identifying of fake details if any, and thus contractor could be even blacklisted for all of his future works. The application of Filter 03 helps in prior quantity and cost estimation works from both client and contractors side. This helps in prior basis of identifying the work flow, which allows contractors for pre-scheduling the project work for future timely completion. Thus all the filters give a combine contribution in selecting an apt candidate based on price and value based environment.

Even from Six sigma model results it is found that the selected contractors has minimum number of defects in his project works carried out. Thus on the basis of no. of defects assessed and no. of opportunities to assess the defects, the sigma level of each contractor could be achieved. This sigma level can also give prediction of the reliability of the contractor in the future projects to be carried out. Thus in this research work, on basis of sigma level obtained, it can be concluded that filter process of best value model proves to be successful for obtaining the suitable Contractor for a project.

6.3 Scope for future work

The above studied model proved to be reasonable and feasible, and showed a satisfactory performance. It also demonstrated its ability to predict the suitable candidates. Further work is required to develop a soft computed generalised project based model, which will carry a complete regional database of contractors and vendors. This contractors and vendors can be defined by the sigma levels on basis of their performance certificates and validation of previous works. Also the weighted scale can be developed by Analytic Hierarchy Model, Multi-criteria model and compared with the current system of ranking. Also a generalised relation can be developed among the major CSC attributes and a relationship can be developed among various parametric variables.

REFERENCES

Abdelrahman, M., Zayed, T., and Elyamany, A. (2008). “Best-value model based on project specific characteristics.” Journal of Construction Engineering and Management, 134(3), 179–188.

Al-Sobei, O., Arditi, D., Polat, G.(2005), “Managing Owner’s Risk of Contractor Default”, 131(9) pp. 973-978.

Araujo, M., Alencar, L.H., Mota, (2015), C., “Contractor Selection in Construction Industry: A Multicriteria Model.”, IEEE, 519-523.

Areola, M. K. (1997). “A key sector suffering from funding constraints and irregularities.” Pak. Gulf Economist, 97(15).

Arlbjorn, J., and Freytag, P. (2012). “Public procurement vs. private purchasing: Is there any foundation for comparing and learning across the sectors?”, International Journal of Public Sector Management, 25(3), pp.203–220.

Barrie, D., and Paulson, B. (1992), Professional construction management, 3rd Ed., McGraw-Hill, New York.

Bernold, L.,Treseler, J. (1991), “Vendor Analysis for Best buy in Construction”, Journal of Construction Engineering & Management”,117(4), pp 645-658.

Burati, J. L., Mathews, M. F., and Kalidindi, S. N. (1991). “Quality management in the construction industry.” ,Journal of Construction Engineering and Management,117(2), 341–359.

Butt, Thomas K., and Clinton, John S. E. (2005). “Limiting construction failure losses—A challenge for the insurance industry”, ⟨http://www.intres.com/inpage/pub/ construction_ failure.html⟩ (Mar. 31, 2009).

Cheng, E.W. L., and Li, H. (2004). “Contractor selection using the analytic network process.” Constr. Manage. Econ., 22(10), 1021–1032.

Desale, S.V., Deodhar, S.V., “Lean six sigma principal in construction: A literature review related to abstract”.

El-Sawalhi, N., Eaton, D. and Rustom, R. (2007), “Contractor pre-qualification model: state-of-the-art.”, International Journal of Project Management, 25(5), 465–74.

Elyamany, A., Abdelrahman, M.,(2010), "Contractor Performance Evaluation for the Best Value of Superpave Projects", Journal of Construction Engineering and Management, 136(5), 606-614.

Flynn, B. B., Schroeder, R. G., and Sakakibara, S. (1994). "A framework for quality management research and an associated measurement instrument." J. Oper. Manage., 11(4), 339–366.

Fong, P. S., and Choi, S. K. (2000), "Final contractor selection using analytical hierarchy process." Constr. Manage. Econom., 18, 547–557.

Gale, B. T., and Swire, D. J. (2006). "Customer value accounting for value based pricing," J. Prof. Pricing, 3rd Quarter, 30–34.

Georgy, M. E., Change, L., and Lei, Zhang (2005). "Engineering performance in the U.S. industrial construction sector." Cost Eng., 47(1), 27–36.

Gransberg, D., Ellicott, M.A. (1997), "Best Value Contracting Criteria", Journal of Cost Engineering, 39(6), 31-34.

Gransberg, D., Senadheera, S.P. (1996), "Design-Build Contract award methods for transportation projects", Journal of Transportation Engineering, 125(6), 565-567.

Gransberg, D., Koch, J.E., Molenaar, K.R. (2006), "Preparing for design-build projects: A primer for owners, engineers, and contractors",ASCE, Reston.

Han, S. H., Chae, M. J., Soon, K., and Ryu, H. D. (2008). "Six sigma based approach to improve performance in construction operations."J. Manage. Eng., 24(1), 21–31.

Hatush, Z., and Skitmore, M. 1997 . "Criteria for contractor selection", Construction management Economics, 15, pp. 19-38.

Hatush, Z., and Skitmore, M. 1998 . "Contractor selection using multicriteria utility theory: An additive model." Build. Environ., 33(2), 148–164.

Holt, G. D., Olomolaiye, P. O., and Harris, F. C. 1995 . "A review of contractor selection practices in the U.K. construction industry. Build. Environ., 30(5) , 533–561.

Kashiwagi, D., and Byfield, R. (2002). "Testing of minimization of subjectivity in best value procurement by using artificial intelligence systems in state of Utah procurement." J. Constr. Eng. Manage.,128(6), 496–502.

Lambropoulos, S. (2007). "The use of time and cost utility for construction contract award under European Union Legislation." Build. Environ., 42(1), 452–463.

Mahdi, I. M., Riley, M. J., Fereig, S. M., and Alex, A. P. 2002 . "A multicriteria approach to contractor selection." Engineering, Construction and Architectural Management, 9(1), pp. 29–37.

Merna, A., and Smith, N. J.(1990) . "Bid evaluation for the U.K. public sector construction contracts." Proceedings of the Institution of Civil Engineers, 88(1),pp. 91–105.

Muhwezi, L.,Acai, J.,Otim, G., "An Assessment of the Factors Causing Delays on Building Construction Projects in Uganda", 2014, International Journal of Construction Engineering and Management, 3(1),pp 13-23.

Murray, Myles (1993). "A construction contract for the year 2000." Concr.Int., 15(6), 60–61.

Naval Facilities Engineering Command. Southern Division (NAVFAC 1996) . "Instructions for developing request or proposals for source selection design/build projects.", Specification instruction 00011,Sourthern Division, Pensacola.

Park,J.,Ojiako,U.,Williams, T., Chipulu,M.(2014), "Practical Tool for Assessing Best value at the procurement Stage of Public Building in Korea", Journal of Management in Engineering, 31(5).

Performance-Based Studies Research Group at Arizona State Univ. (PBSRG). (2009). "Case studies and results."

Pheng, L.S., Hui, M.S. (2004), "Implementing and Applying Six Sigma in construction", Journal of Construction Engineering and Management, 130(4), pp. 482-489.

Russell, J. S., Hancher, D. E., and Skibniewski, M. J. 1992 . "Contractor prequalification data for construction owners." Construction Management and Economics, 10(2) ,pp. 117–135.

Sawant, S.P., Pataskar, S.V.(2014), "Applying Six Sigma Principles in Construction Industry for Quality Improvement", ICAET.

Scott, S., Molenaar, K., Gransberg, D., and Smith, N. 2006 . "Best-value procurement methods for highway construction projects." Rep. No. 561, Project No. 10-61, NCHRP, Transportation Research Board, National Research Council, Washington, D.C.

"Shortages driving price increase in bidding." (2005). Construction News,71(25), 12.

Singh, D., Tiong, R., (2006), "Contractor Selection Criteria: Investigation of Opinions of Singapore Construction Practitioners", Journal of Construction Engineering and Management, 132(9), pp. 998-1008.

Sullivan, K., and Guo, Y. (2009). "Contractor cash flow and profitability analysis between best value and low bid." Cost Eng., 51(9), 16–20.

Sullivan, K., Kashiwagi, D., and Chong, N. (2009). “The influence of an information environment on a construction organization’s culture: A case study.” Adv. Civ. Eng., 2009, 1–10

Sullivan,K. (2011), “Quality Management Programs in the Construction Industry: Best Value Compared With Other Methodologies”, Journal of Management and Engineering, 27(4), pp. 210-219.

U.S. Postal Service. 2005 . Handbook P-2: Design and construction purchasing practices, Purchasing and Materials, United States Postal Service, Washington, D.

Wong, C. H., Holt, G. D., and Harris, P. (2001). “Multicriteria selection or lowest price? Investigation of U.K. construction clients’ tender evaluation preferences.” Eng., Constr., Archit. Manage., 8(4), 257–241.

Yu, W.,Wang, K. (2012), “ Best Value or Lowest Bid? A Quantitative Perspective” ,Journal of Construction.Engineering and Management, 138(1) pp. 128-134.

Zack, J. (2006), “Cost Engineers and risk analysis impacting project owners”, Construction Engineering, 48(12), pp. 3-5.

Zhang, X, (2006), “Public Clients’ Best Value Perspectives of Public Private Partnerships in Infrastructure Development”, Journal of Construction Engineering and Management, 132(2),pp. 107-114.

APPENDIX

Appendix 1. Contracting Firms

Sr.no	Contracting Firms involved in the process
1	Sri Avantika Contractors Pvt Ltd.
2	Vijay Nirman Company Pvt Ltd.
3	A K Enterprises
4	BVSR Constructions Pvt Ltd.
5	Hari Krishna Engineering Pvt Ltd. Civil and Structural Contractors
6	Vibhuti Constructions Pvt Ltd.
7	Smith Engineering

Appendix 2. BVj Model for Filter 01

Crit-eria Nos	Contractor Selection Criteria Particulars	Weightage Obtained through Mapping	Contractor 01		Contractor 02		Contractor 03		Contractor 04		Contractor 05		Contractor 06		Contractor 07	
		(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)	(Psi)	(Psi)x(Wi)
C1	Name of the Company (Type)	0.270	5	1.35	5	1.35	1	0.27	1	0.27	5	1.35	5	1.35	1	0.27
C2	Contact Details	0.117	3	0.351	4	0.468	3	0.351	3	0.351	4	0.468	3	0.351	2	0.234
C3	Registration No	0.117	5	0.585	5	0.585	5	0.585	5	0.585	5	0.585	5	0.585	5	0.585
C4	Paid - up Capital (CR)	0.387	3	1.161	5	1.935	1	0.387	1	0.387	1	0.387	1	0.387	1	0.387
C5	Total Work Experience (years)	0.117	3	0.351	3	0.351	1	0.117	3	0.351	2	0.234	2	0.234	2	0.234
C6	Experience of Similar Work	0.438	2	0.876	2	0.876	1	0.438	2	0.876	1	0.438	2	0.876	1	0.438
C7	Performance Certificate of above work	0.555	1	0.555	1	0.555	1	0.555	0	0	1	0.555	0	0	1	0.555
C8	Similar Completed Work Order Costing Not Less than specified Amount (In CR)	0.883	5	4.415	5	4.415	1	0.883	0	0	3	2.649	0	0	3	2.649
C9	No. of Work Order Carried Out For Mentioned Amount	0.438	1	0.438	1	0.438	1	0.438	0	0	1	0.438	0	0	1	0.438
C10	Performance Certificate of above work	0.555	1	0.555	1	0.555	0	0	1	0.555	1	0.555	0	0	1	0.555

C11	Similar Completed Work Order Costing Not Less than specified Amount (In CR)	0.883	1	0.883	1	0.883	0	0	1	0.883	1	0.883	0	0	1	0.883
C12	No. of Work Order Carried Out For Mentioned Amount	0.438	1	0.438	1	0.438	0	0	1	0.438	1	0.438	0	0	1	0.438
C13	Penalty Incurred For the Project	0.555	5	2.775	5	2.775	5	2.775	5	2.775	5	2.775	1	0.555	5	2.775
C14	Last Three Years Audit Report	0.153	1	0.153	1	0.153	0	0	1	0.153	1	0.153	1	0.153	1	0.153
C15	Average Financial Turnover (CR)	0.153	5	0.765	5	0.765	0	0	5	0.765	4	0.612	5	0.765	5	0.765
C16	Total (IT/VAT/TIN/ST/PF Nos.) Uploaded	0.153	5	0.765	5	0.765	5	0.765	4	0.612	4	0.612	4	0.612	4	0.612
C17	Bank Solvency Certificate	0.153	5	0.765	5	0.765	0	0	5	0.765	5	0.765	0	0	5	0.765
C18	Key Personnel Educational Qualification	0.526	5	2.63	5	2.63	5	2.63	5	2.63	5	2.63	1	0.526	2	1.052
C19	Work Experience of key personnel	0.526	5	2.63	5	2.63	4	2.104	4	2.104	5	2.63	4	2.104	5	2.63
C20	No. Of Engineers in Firm with B. E or Higher Qualification	0.292	5	1.46	5	1.46	1	0.292	4	1.168	4	1.168	5	1.46	4	1.168
C21	No.of Engineers in Firm with Diploma in Construction/Civil Engineering	0.292	5	1.46	5	1.46	4	1.168	5	1.46	5	1.46	5	1.46	5	1.46
C22	No. of Supervisors	0.292	5	1.46	5	1.46	5	1.46	5	1.46	5	1.46	5	1.46	5	1.46

C23	No.of Permanent Administrative Staff	0.292	5	1.46	5	1.46	3	0.876	5	1.46	5	1.46	1	0.292	3	0.876
C24	No.of Permanent Technical Staff	0.526	5	2.63	5	2.63	5	2.63	5	2.63	5	2.63	3	1.578	5	2.63
C25	No.of Licensed Site Engineers	0.526	5	2.63	5	2.63	1	0.526	5	2.63	5	2.63	1	0.526	4	2.104
C26	No. of Licensed Surveyor	0.526	5	2.63	5	2.63	1	0.526	5	2.63	5	2.63	5	2.63	5	2.63
C27	No. of Ongoing Project	0.153	4	0.612	1	0.153	4	0.612	1	0.153	4	0.612	4	0.612	1	0.153
C28	List of Machinery with Available Nos	0.234	1	0.234	1	0.234	0	0	1	0.234	1	0.234	0	0	1	0.234
C29	No.of Construction Machinery Owned By the Company	0.679	4	2.716	4	2.716	0	0	4	2.716	1	0.679	0	0	4	2.716
C30	No.of Machinery Equiped with on - going project	0.234	3	0.702	5	1.17	0	0	4	0.936	2	0.468	0	0	3	0.702
C31	Project Manger Appointed	0.526	5	2.63	5	2.63	5	2.63	5	2.63	5	2.63	1	0.526	5	2.63
C32	No.of Labors tied up with/ No.of Direct Workers Available	0.292	5	1.46	5	1.46	3	0.876	4	1.168	3	0.876	2	0.584	2	0.584
C33	No.of Vendors	0.496	3	1.488	3	1.488	2	0.992	3	1.488	4	1.984	3	1.488	4	1.984
C34	No.of Sub-Contractors appointed in previous similar work	0.438	4	1.752	3	1.314	5	2.19	2	0.876	3	1.314	4	1.752	4	1.752
C35	Quality Testing Lab	0.643	4	2.572	5	3.215	1	0.643	4	2.572	5	3.215	1	0.643	5	3.215
C36	Safety officer Appointed	0.409	5	2.045	5	2.045	1	0.409	5	2.045	5	2.045	1	0.409	5	2.045
C37	No.of Fatalities on site till date	0.321	4	1.284	4	1.284	5	1.605	4	1.284	4	1.284	4	1.284	4	1.284
C38	No.of Injuries on site till date	0.321	4	1.284	3	0.963	4	1.284	4	1.284	3	0.963	5	1.605	4	1.284

C39	List of Safety Equipment Uploaded	0.117	1	0.117	1	0.117	0	0	0	0	1	0.117	0	0	1	0.117
C40	OSHA Safety Rule followed on site	0.117	5	0.585	5	0.585	0	0	5	0.585	5	0.585	0	0	5	0.585
C41	Personal Protective Equipments (PPE) Available on site	0.117	5	0.585	5	0.585	0	0	5	0.585	5	0.585	0	0	5	0.585
		Total (BVj)	**56.237**		**57.021**		**31.017**		**46.494**		**50.186**		**26.807**		**48.616**	

Appendix 3. BVj model for Filter 03

SR. NO	DESCRIPTION OF WORK	QTY	UNIT	RATE	C1				C2				C5			
				FIG (RS)	Qty	Cost	Rank	BVj	Qty	Cost	Rank	BVj	Qty	Cost	Rank	BVj
PILING:																
1	Carrying out Vertical load testing of 500mm dia pile in accordance with IS Code of practice IS:2911 (Part IV) including installation of loading platform and preperation of pile head or constructon of test cap and dismantelling of test cap after test etc. cpmplete as per specification and direction of EIC. Loading to be done upto 1.5 times of the design load or upto the load at which the total settlement reaches 12mm for single pile, whichever is earlier.	**2**	**NO.**	**94,293**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
2	Carrying out Vertical load testing of 600mm dia pile in accordance with IS Code of practice IS:2911 (Part IV) including installation of loading platform and preperation of pile head or constructon of test cap and dismantelling of test cap after test etc. cpmplete as per specification and direction of EIC. Loading to be done upto 1.5 times of the design load or upto the load at which the total settlement reaches 12mm for single pile, whichever is earlier.	**2**	**NO.**	**1,30,560**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
3	Boring,Providing and installing Bored cast-in-situ R.C.C. pile of 500 mm diameter & length below the pile cap M35 in Cement Concrete, to carry a safe working load not less than specified, including Chieselling in Hard Rock upto 1.5D(If Required), excluding the cost of steel reinforcement but including the cost of boring with, bentonite solution & temporary casing of appropriate lenght for setting out & removal of same and the length of the pile to be embeded in the pile cap e.t.c. all complete, including removal of excavated earth from IOCL compound with all lifts & leads (Length of Pile for Payment shall be measured upto bottom of Pile Cap).	**718**	**R.M**	**2931**	0	0	1	**0**	1	1	3	**3**	1	1	2	**2**
4	Boring,Providing and installing Bored cast-in-situ R.C.C. pile of 600 mm diameter & length below the pile cap M35 in Cement Concrete, to carry a safe working load not less than specified, including Chieselling in Hard Rock upto 1.5D(If Required), excluding the cost of steel reinforcement but including the cost of boring with, bentonite solution & temporary casing of appropriate lenght for setting out & removal of same and the length of the pile to be embeded in the pile cap e.t.c. all complete, including removal of excavated earth from IOCL compound with all lifts & leads (Length of Pile for Payment shall be measured upto bottom of Pile Cap).	**5166**	**R.M**	**3741**	0	0	1	**0**	1	1	3	**3**	1	1	2	**2**

EARTHWORK IN EXCAVATION:																
5	Earth-work in excavation for foundation of Footings (All Types), trenches,Walls, drains, under ground water tanks, soakpit, septic tanks, Yards etc. in all types of soil including soil mixed with boulders, Kankars etc. in both dry/wet conditions including shoring of trenches wherever required, bailing/pumping out water,dressing of sides and ramming of bottom, backfilling with selected excavated earth in layers not exceeding 250mm in depth including watering, consolidating Each layer to be compacted by mechanical / manual means etc. and disposal of surplus excavated earth after backfilling, & carting away debris outside IOCL premises etc. complete as directed by EIC.															
A)	Depth upto 1.5 M	**167 0**	**CU M**	**261**	1	1	2	**2**	1	0	1	**0**	1	1	3	**3**
MURRUM FILLING																
6	Filling murrum in plinth , underfloors and other similar situations with approved quality murrum brought by the contractor at his cost from outside, irrespective of any lead including loading, unloading, spreading in layers not exceeding 250 mm thick, breaking of clods, levelling and grading, watering and consoildation by mechanical / manual means & or as directed byE.I.C., (Net consolidated volume shall be considered for the purpose of the payment).All royalties & Taxes levied by local/State Government Authority shall be borne by the contractor.	**125 31**	**CU M**	**441**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
RUBBLE SOLING																
7	Providing and laying 230 mm thick (after consolidation) dry hard rubble packing underfloor, ramps, walls, foundations, trenches etc. and for similar situations at plinth level / below plinth level including laying in regular lines, levels, interstices filled with smaller stones/ chips of appropriate size and sand, consolidated with murrum filled in gaps, watering and consoildation by mechanical / manual means (Net consolidated volume shall be considered for the purpose of the payment)as specified and finished to the required levels etc. as directed.	**243 9**	**CU M**	**1,353**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
PLAIN & REINFORCED CEMENT CONCRETE WORK :																
8	Providing, mixing, placing, compacting and curing Plain cement concrete mix 1:3:6 with graded stone aggregate 20 mm nominal size for foundation, underfloors, Drive ways, open yards etc. complete including the cost of unwrought form work wherever required.	**132**	**CU M**	**4357**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
9	Providing, mixing, placing, compacting and curing plain cement concrete mix 1:2:4 with graded stone aggregate 20 MM nominal size including the cost of unwrought form work/scafolding etc. complete for Plinth Floor or	**106 4**	**CU M**	**5039**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**

	any other P.C.C etc.														
10	Providing, mixing, placing, compacting and curing plain cement concrete mix 1:3:6 with graded stone aggregate 20 MM nominal size including the cost of unwrought form work/scafolding etc. complete for Plinth protection etc. The above work includes placing concrete above soling, including wastages due to loss of concrete in voids. No extra payments for loss of concrete due to voids.	**530**	**CU M**	**4392**	1	0	1	**0**	1	1	3	**3**	1	1	2	**2**
11	Providing, mixing, placing, compacting and curing plain cement concrete mix 1:2:4 with graded stone aggregate 20 MM nominal size including the cost of unwrought form work/scafolding etc. complete for sill, coping, bed block, flooring etc at any level, size, shape upto five floors..	**26**	**CU M**	**5,492**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
REINFORCED CEMENT CONCRETE :M20															
13	Providing, mixing, placing, vibrating, curing, reinforced cement concrete grade M-20 (with minimum cement content of 410 kg per Cum. of finished concrete) in foundations, footings, bases, columns , plinth/grade beams, tanks/equipment foundation, cable trenches, pedestals, rafts, supports, walls etc. upto plinth level using graded stone aggregate 20 mm nominal size including the cost of form work (plain and curved), de-shuttering of form work but excluding the cost of reinforcement complete;	**85**	**CU M**	**8052**	1	1	2	**2**	1	1	3	**3**	1	0	1	**0**
14	a. Contractor shall be permitted to convert design mix of concrete into suitable volumetric mix in the case of smaller volume of concreting in order to achieve required design strength. The use of Ready - Mix / Volumetric mix shall be as per the discretion of the Engineer - In - Charge.				1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
	b. Unless stated otherwise, the rates shall include the works to be carried out at all levels and for all linear														
	shapes and sizes including cornice & moulding as per the drawings using steel form work.														
	c. Rates shall also include the watering/ curing as required.														
	d. Unless otherwise specified, all shuttering above ground level shall be with waterproof plywood/ Steel as per latest IS codes & all supporting like H-Frames, Props etc shall be of steel.														
	e. For all concreting works, mechanical mixer, vibrator shall be used.														
	-														
A)	Pile Cap/Footing	**301**	**CU**	**6205**	1	0	1	**0**	1	1	3	**3**	1	1	2	**2**

			M													
B)	Beams (plinth/ lintel/floor/ roof) upto Any Height.	**464**	**CU M**	**6769**	1	0	2	**0**	1	1	3	**3**	1	1	1	**1**
C)	Columns, All Levels upto Any Height.	**597**	**CU M**	**6437**	1	1	2	**2**	1	0	1	**0**	1	1	3	**3**
D)	Roof slabs At Levels Upto Any Height.	**98**	**CU M**	**7366**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
E)	Sunshades(including rain drip bond) upto Any Height	**4**	**CU M**	**7763**	0	0	2	**0**	1	1	3	**3**	1	1	1	**1**
F)	Lintels / Pardi / Trenches / Walls.Upto Any Height	**45**	**CU M**	**6686**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
G)	R.C.C. DRAINS	**82**	**CU M**	**6,769.00**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
H)	CULVERT	**38**	**CU M**	**7,929.00**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
I)	WATER TANK	**38**	**CU M**	**7,598.00**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
REINFORCEMENT STEEL																
15	Providing High Yield Strength Deformed bars (Fe 415) conforming to IS 1786 for reinforcement in all R.C.C work (cast in situ and precast) including cutting, bending, binding and placing in position in all floors and at all levels / heights etc. complete complete as per drawing. (Rate includes the cost of Galvanised binding wire which shall not be measured for the purpose of payment.) Also authorised laps & spacer bar except chairs shall not be measured for payment.	**319081**	**KGS**	**65**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
STRUCTURAL STEEL																
16	Supplying, transporting, fabricating, erecting in position Structural steel work in single and built up section fixed with or without connecting plate in rolled steel joists, flats, tees, angles, channels, plates etc. including bracing, floor beams, pipe racks, gantry girders, monorails, staircases, ladders, protection angles, portal frames, pipe supports, hangers, cross overs, roof trusses, purlins, bracings, tie runners etc. including surface preparation by blasting to SA 2.5 ,providing and applying two coats of F4 paint over one coats of P1 primer and 1 coat of U1 undercoat as per specifications attached including staging, scaffolding complete.(No measurement shall be taken for nut,bolt,washer splice plate & gusset plate). payment for foundation bolts for pumps and rod over pedestals shall however be made under this item.	**619224**	**KGS**	**74**	1	1	2	**2**	1	1	3	**3**	0	1	1	**0**
BRICK WORK																

17	Providing and laying 230 mm thick and above, Brick masonary using locally available burnt moulded clay bricks (minimum compressive strength of 35 KSC) at all levels in cement mortar 1:4 including scaffolding, curing etc. complete.	**542**	**CU M**	**3,696**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
18	Providing & laying half brick masonary of 115mm(4.5inch) or 150MM(6inch) wide, Brick masonary using locally available Burnt moulded clay bricks (minimum compressive strength of 35 KSC) at all levels in cement mortar 1:4 including scaffolding, curing etc. complete. R.C.C.Coping & reinforcement shall be paid seperately under relevent item..	**47**	**CU M**	**3,436**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
PLASTERING																
19	Providing and applying 20 MM thick cement plaster to all external surfaces and at all levels in two coats with base coat of 12 mm thick in CM 1:5 & finish coat of 8 mm thick in CM 1:3 including finishing the surface to uniform rough texture (sponge finish) by applying neat coat of cement including staging, curing etc complete as per technical specifications and site directions complete.	**5432**	**SQ M**	**225**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
	Note: a) Hacking of RCC surfaces shall be done when the concrete is green in order to provide key to plaster. b) Plastering shall be done using 1 Kg of water proofing compound to every bag of cement used. c) The above cost includes the rates for making grooves, Plaster Band, Elevation Plaster Treatment & Etc in any shape & size in plaster or as directed by EIC.															
20	Providing and applying 20 MM thick cement decorative plaster to all external surfaces and at all levels in two coats with base coat of 12 mm thick in CM 1:5 & finish coat of 8 mm thick in CM 1:3 including finishing the surface to uniform rough texture (sponge finish) by applying neat coat of cement including staging, curing etc complete as per technical specifications and site directions complete.	**255**	**SQ M**	**275**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
	Note: a) Hacking of RCC surfaces shall be done when the concrete is green in order to provide key to plaster. b) Plastering shall be done using 1 Kg of water proofing compound to every bag of cement used. c) The above cost includes the rates for making grooves, Plaster Band, Elevation Plaster Treatment & Etc in any shape & size in plaster or as directed by EIC.															

21	Providing and applying 12 MM thick Cement plaster in cement mortar 1 : 4, finished smooth with 2 mm thick Plaster of Paris putty over plasteres surface to prepare th surface even & smooth complete in line & plumb as directed by EIC for all internal wall or roof surfaces including surface preparation, hacking of all R.C.C surfaces including scaffolding, staging, curing etc. at all levels / heights complete as per specification.	**324 4**	**SQ M**	**162**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
WATER PROOFING																
22	Notes : All Waterproofing work shall, carry 10 years written guarantee on stamp paper.															
	Unless otherwise stated, measurements shall be on plan area basis. (No extra payment shall be made for vertical portions at junctions of walls and floor/ Roof Slabs.)															
	Providing and laying integral cement based water proofing treatment including preparation on surface as required for treatment of roofs balconies, terraces etc consisting of following operations : a) Applying a slurry coat of neat cement using 2.75 kg/sqm. of cement admixed with water proofing compound conforming to IS 2645 and approved by Engineer-in-charge over the RCC slab including adjoining walls upto 300 mm height including cleaning the surface before treatment. b) Laying brick bats with mortar using broken bricks / brick bats 25 mm to 115 mm size with 50% of cement mortar 1:5 (1 cement : 5 coarse sand) admixed with water proofing compound conforming to IS : 2645 and approved by Engineer-in-charge over 20 mm thick layer of cement mortar of mix 1:5 (1 cement : 5 coarse sand) admixed with water proofing compound conforming to IS : 2645 and approved by Engineer-in-charge to required slope and treating similary the adjoining walls upto 300mm height including rounding of juctions of walls and slabs															

	c) After two days of proper curing applying a second coat of cement slurry using 2..75kg/sqm of cement admixed with water proofing compound conforming to IS: 2645 and approved by Engineer-in-charge. d) Finishing the surface with 20mm thick jointless cement mortar of mix 1:4 (1 cement : 4 coarse sand) admixed water proofing compound conforming to IS: 2645 and approved by Engineer in charge including laying glass fibre cloth of approved quality in top layer of plaster and finally finishing the surface with trowel with neat cement slurry and making pattern of 300x300 mm square 3 mm deep. e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operation to be done in order and as directed and specified by the Engineer-in-charge :															
	Note: The entire job shall be carried out using mixing 1 KG of IMPERMO water proofing compound with every 50 KG of cement.															
	With average thickness of 120mm and minimum thickness at khurra as 65mm	**298**	**SQ M**	**784**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
23	Providing and laying water proofing treatment in R.C.C. Sun Shade/Chajja etc. by applying cement slurry mixed with water proofing cement compound consisting of applying : a) First layer of slurry of cement @ 0.488 kg / sqm mixed with water proofing cement compound @ 0.253 kg / sqm.This layer will be allowed ti air cure for 4 hours . b) Second layer of slurry of cement @ 0.242 kg / sqm mixed with water proofing cement compound @ 0.126 kg / sqm.This layer will be allowed ti air cure for 4 hours followed with water curing for 48 hours. The rate includes preparation of surface, treatment and sealing of all joints, corners, junctions of pipes and masonry with polymer mixed slurry. The above work includes adjoining walls upto 300mm height including cleaning the surface before treatment. Area of 300mm vertical portion shall not be considered for payment purpose.	**31**	**SQ M**	**232**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
	PAINTING															
24	Providing and applying two or more coats of plastic emulsion paint (lead free) of approved brand and manufacturer for the walls to give an even shade over and including one priming coat of plastic emulsion primer to all internal surfaces of building including surface preparation by Application of Putty of any thickness over rough cast plaster so as to remove surface imperfections(so as to acheive smooth & perfect surface) , scaffolding etc. complete at all floors and at all levels. The work also includes making of horizontal grooves in putty along the room at a spacing of minimum 1m c/c or as directed by EIC .	**477**	**SQ M**	**177**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**

25	Providing and applying two or more coats of oil bound washable distemper of approved brand and manufacture for the walls to give an even shade over and including a priming coat of distemper primer to all internal surfaces of building including surface preparation by Application of Putty of any thickness over rough cast plaster so as to remove surface imperfections(so as to acheive smooth & perfect surface) , scaffolding etc. complete at all floors and at all levels.	**2248**	**SQ M**	**61**	1	0	1	**0**	1	1	3	**3**	1	1	2	**2**
26	Providing and applying 3 or more coats of 100 % Elestromeric single component of 200 micron DFT Acrylic paint having more than 400% elongation of brand Shalicryl 215 of STP LTD. on all plastered surface to give an even shade including surface preparation, scafolding, curing etc. complete at all levels and heights etc complete.	**5263**	**SQ M**	**190**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
FLOORING																
27	Providing and laying first quality Vitrified tiles (thickness- 10 mm) of approved make, colour & shade in size 600 x 600 mm for flooring laid on average 20 mm thick cement mortar 1 :4, including applying cement slurry (3.3 kg of cement per sqm) to the sub base; applying neat cement float on the backside of tiles and finishing the joints with white cement mixed with pigments to match the shade of tiles, cutting of tiles wherever required, curing etc. complete.															
A	Flooring	**310**	**SQ M**	**2,117**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
B	Skirting 100 mm. High (the cement mortar base shall not be more than 12 mm)	**24**	**SQ M**	**2,223**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
28	Providing and laying first quality Vitrified tiles (thickness- 10 mm) of approved make, colour & shade in size 300 x 600 mm for walls laid on average 20 mm thick cement mortar 1 :4, including applying cement slurry (3.3 kg of cement per sqm) to the sub base; applying neat cement float on the backside of tiles and finishing the joints with white cement mixed with pigments to match the shade of tiles, cutting of tiles wherever required, curing etc. complete.															
A	WALLS/DADO	**405**	**SQ M**	**2,621**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
29	Providing and laying first quality *non skid* Vitrified tiles (thickness- 10 mm) of approved make, colour & shade in size 300 x 300 mm for flooring laid on average 20 mm thick cement mortar 1 :4, including applying cement slurry (3.3 kg of cement per sqm) to the sub base; applying neat cement float on the backside of tiles and finishing the joints with white cement mixed with pigments to match the shade of tiles, cutting of tiles wherever required, curing etc. complete.															

A	Flooring	**63**	**SQ M**	**2,749**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
30	Providing & Laying M30 grade 150mm thick concrete in floors well compacted, mechanically vibrated, dewatered by vacuum process “TREMIX” floated with floated power trowelled to get desired smooth finishing, to required levels, over a leveling course, including M. S. shuttering, curing etc. complete. The panel size shall as per the site requirement and shall suit the conditions at site. The contraction / sawed joints to be formed by making grooves of min 25mm depth with a nominal width of minimum 5mm using appropriate mechanical concrete cutter @ 4m c/c along length & filling the same with Shaliseal Pu, and operation should be carried out as soon as concrete is ready to accept the saw cut without trowelling. The joints should be filled with Shaliseal Pu, polyurethane for top 10mm The construction joint is formed by square edge. Providing PP Fibre 1.2 Kg/m3. The Nominal reinforcement of 8mm dia 150 c/c Both ways . steel shall be provided, but paid seperately in Providing & laying Reinfocement.																
	Application of non mettalic hardener Shalifloor NM @ 7 Kg / Sqm shall be sprinkled over green concrete 1/3rd of the dryshake shall be broad-casted in first pass and same is floated with power floater, remaining 2/3rd of dry shake is sprinkled in next pass thus the floor laid is floated & trowelled to acquire smooth finish.																
	Curing for 7 days with water.																
A)	Flooring M : 30	**103 99**	**SQ M**	**2,082**	0	1	1	**0**	1	1	2	**2**	1	1	3	**3**
31	Providing and laying Flame Processed Granite of approved shade,pattern, texture & colour in part or whole, 20mm minimum thick, in single piece (length not exceeding 2m), for treads and risers of staircase, Landings, plinth protection, platforms, corridors, flooring, wall etc. laid on 12mm thick (min) cement mortar 1:3 and jointed with cement slurry mixed with pigment to match the shade of the stone wherever required including nosing, etc. complete as required.	**58**	**SQ M**	**4,461**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
32	Providing and laying machine cut Granite of approved shade,pattern, texture & colour, 12mm minimum thick, using various combination of size, viz. 450x450mm, 600x600mm, 900x900mm, 300x600mm, 300x900mm or as directed by E.I.C but ofsize not more than 1mx1m in for walls etc. laid on 12mm thick (min) cement mortar 1:3 and jointed with cement slurry mixed with pigment to match the shade of the stone wherever required including nosing, etc. complete as required.	**78**	**SQ M**	**2,368**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**

33	Providing and laying machine cut machine polished Kadappa stone platform & or verticals of 25mm minimum thick, in single peice to the extent possible complete as required in any shape size & pattern, Complete with groove cutting in floor or walls/partitions or & as directed by EIC.	**17**	**SQ M**	**1,558**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
34	Providing and laying machine cut skirting of Kota stone (of approved colour) 25mm minimum thick, for skirting 300 mm. high, laid on average 12mm thick cement mortar 1 : 4 and jointed with cement slurry mixed with pigment to match the shade of stone wherever required to suit the flooring pattern and polishing etc. complete including finishing the top edge of skirting with plastered surface.	**264**	**SQ M**	**1,673**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
35	Providing and laying machine cut machine polished Black Granite stone slab 20mm minimum thick, in Window frames 280 mm. wide & above laid over 20 mm thick (average) in cement mortar 1 : 4 and jointed with grey cement slurry mixed with pigment to match the shade of stone slab including machine cutting of stone wherever required, rubbing and polishing etc. complete. (Granite shall be black granite of best quality available); item also includes providing half / full round moulding to exposed edges.	**64**	**SQ M**	**4,260**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
36	Providing and laying machine cut machine polished Black Granite stone slab 20mm minimum thick, in Door frames 280 mm. wide & above laid over 20 mm thick (average) in cement mortar 1 : 4 and jointed with grey cement slurry mixed with pigment to match the shade of stone slab including machine cutting of stone wherever required, rubbing and polishing etc. complete. (Granite shall be black granite of best quality available); item also includes providing half / full round moulding to exposed edges.	**56**	**SQ M**	**4,260**	1	1	2	**2**	1	1	3	**3**	1	0	1	**0**
P.V.C. DOORS (DOORS MENTIONED IN DRAWINGS ARE TO BE READ AS PVC DOORS)																

37	Providing & fixing 30mm thick factory made polyvinyl chloride (PVC) door shutter made of styles and rails of a UPVC hollow section of size 60x30 mm and wall thickness 2 mm ± 0.2 mm with inbuilt decorative moulding edging on both side.the styles and rails mitred and joined at the corners by means of M.S. galvanised/plastic brackets of size 75x220 mm having wall thickness 1.0 mm and stainless steel screws. the styles of the shutter reinforced by inserting galvanised M.S. tube of size 25x20 mm and 1 mm ± 0.1 mm wall thickness. the lock rail made up of 'H' section a UPVC hollw section of size 100x30 mm and 2 mm ± 0.2 mm wall thickness fixed to the shutter styles by means of plastic/galvanised M.S.'U' cleats. the shutter frame filled with a UPVC multi-chambered single panel of size not less than 620 mm, having overall thickness of 20 mm and 1 mm ± 0.1 mm wall thickness. the panels filled vertical and tie bar at two places by inserting horizontally 6 mm galvanised M.S. rod and fastened with nuts and washers complete as per manufacturers specification and direction of Engineer-in-charge.															
DOORS																
A	Door of Size (0.75 m x 2.1 m)	**16**	**SQ M**	**3,320**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
B	Door of Size (0.9 m x 2.1 m)	**6**	**SQ M**	**3,320**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
C	Door of Size (1 m x 2.1 m)	**13**	**SQ M**	**3,320**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
D	Door of Size (1.2 m x 2.1 m)	**6**	**SQ M**	**3,320**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
ALLUMINIUM GLAZED DOOR																
38	All Aluminium sections to be used shall be matt finished anodised out of Magnesium Silicon Alloy with an anodised film of approved colour of thickness not less than 15 microns. Alluminium doors and windows shall be fixed on granite/ marble framework. The items shall also include providing and filling approved silicon sealant as required to ensure water tightness, protection of installed items. The rates quoted should also be inclusive of all necessary fittings and hardware as per manufacturer's recommendations required to complerte work in all respects.															

	Supply, fabricating and fixing aluminium anodised approved colour single/double door made out of Jindal section Nos. 4617 (1.892 Kg/Rm) as door outer frame and 4504 (1.505 Kg/Rm) as door verticle, 4506 (1.501 Kg/Rm) as door top and bottom, 4549 (1.679 Kg/Rm) as door middle, with all necessary fittings like heavy duty hinge, locks, tower bolts, latches, handles, rubber gaskets with 10 mm Float Glass on upper half portion & 12 mm thick pre - laminated board on both sides at shutter bottom etc. complete.															
A	Door (1.2 m x 2.1 m) with 10 mm float glass & 12 mm Pre laminated particle board	**2.52**	**SQ M**	**4,624**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
B	Door (1 m x 2.1 m) with 10 mm float glass & 12 mm Pre laminated particle board	**2.1**	**SQ M**	**4,624**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
	ALLUMINIUM WINDOWS															
39	Three Track Windows - Supplying, fabricating and fixing three track sliding windows made out of Jindal sections 8685 (1.659 Kg/Rm) as frame bottom with gutter, 8782 (1.284 Kg/Rm) as frame top & sides, 8604 (0.522 Kg/Rm.) as side frame,8602 (0.663 Kg/Rm) as shutter interlock, 8603 (0.641 Kg/Rm) as shutter top & bottom. with all necessary fittings like window handles, wheels, rubber gasket, locks and top guide with 5.5mm thick black tinted glass etc. complete.															
A	Window marked as W (2.1m x 1.2 m)	**16**	**SQ M**	**4,748**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
B	Window marked as W (1.8m x 1.2 m)	**16**	**SQ M**	**4,748**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
40	Fixed Window -Supplying, fabricating and fixing anodised (15 mircons), aluminium windows fixed															
A	FX SH	**20**	**SQ M**	**3,564**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
41	Louvered Windows - Supplying, fabricating and fixing "N" type ventilator i.e. LOUVERED WINDOW sanpon glazing clips with all necessary fittings like joining clips, rubber gaskets with 4mm float glass etc., complete.															
A	Ventilator marked V size 0.6m. X 0.9m/0.6m. X 0.6m	**7**	**SQ M**	**4,479**	0	1	1	**0**	1	1	3	**3**	1	1	2	**2**
ROOFING & ALLIED WORKS																
42	Providing and fixing 0.58 mm thk (TCT) clip on (standing seam) polyester colour coated galvalume roof sheeting of approved make in roofing at all level with galvanised self driven bolts, PVC rubber washers, GI seam bolts and nuts including cutting of sheets to required size, metring laps, scaffolding, staging etc all complete as per specification and	**107 07**	**SQ M**	**1,094**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**

	manufacturer's instructions															
	Note: Measurement shall be on total area completed and overlaps shall not be considered.															
43	Providing and fixing 0.50 mm thk polyester colour coated galvalume sheeting trapezoidal profile of approved make and shade with all nuts/ bolts etc including cutting of sheets to required length and size, laps, scaffolding, staging etc. as per manufacturer's specifications for cladding works.	**2140**	**SQ M**	**916**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
	Note: Measurement shall be on total area completed and overlaps shall not be considered.															
44	Providing and fixing accessories using 0.50 mm thk polyester colour coated galvanised plain sheets with GI bolts nuts etc for roofing and cladding. The measurement shall be on total length completed and overlaps shall not be paid.															
A	Corner Flashing/Barge Boards (Corner pieces)	**468**	**RM**	**1,094**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
B	Drip flashing pieces	**941**	**RM**	**1,094**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
C	Ridge pieces	**471**	**RM**	**1,094**	1	0	1	**0**	1	1	2	**2**	1	1	3	**3**
D	Gutters of Any size & shape not exceeding 1.5m in total width including cold forming the trapezoidal shape with wings as shown in drawing or as directed by EIC.	**628**	**RM**	**1,751**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
45	Providing and fixing 2 mm thick Embossed clear Polycarbonate sheeting trapezoidal profile of approved make with all nuts, bolts, etc. includign cutting of sheets to required size and length, laps, scaffolding, staging, etc.as per manufacturers specification and instruction for Roofing & cladding.	**536**	**SQ M**	**1,897**	1	1	2	**2**	1	1	3	**3**	1	0	1	**0**
TURBO VENTILATOR																
46	Providing & fixing 24” dia Wind Driven Turbo Ventilator system in Aluminium along with FRP Base Plate of Approved make & type with all fittings, nuts, bolts, etc. including FRP base sheet of approved colour.shape & size including cutting of Galvalume sheets for fixing the Base to required size & length, lap, scafollding, staging, etc as per instructions of EIC.	**108**	**NO**	**8,559**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
LUMPSUM WORK OF TOILETS:																

47	Providing and fixing all sanitary fittings of Cera Brand of approved Model/Color/Shape and fixtures of Jaguar (FLORENTINE Series) including plumbing fittings with pipe lines, Miror, Electronic Automatic Fulshing System of Jaguar or any other Approved brand, Conceal Flush Tank of Cera in W.C., Fixed Soap Dispensers, Hand Towel, Disposable hand Towel, S.S. Towel Rail, Automatic Hot Air Type Hand Drier & etc, whereeverapplicable as per enclosed drawings. complete in all respect as directed by the E.I.C. This item shall alsoinclude Provision of all Plumbig fittings,like Approved Nahani Trap Polyethelene-Aluminium-polyethelene (PE-AL-PE) Composite pressure pipes conforming to IS - 15450 & its required fittings essential for completion of the work. There would not be any restriction on the number of fittings, The above rate should include warranty for the fittings for One Year from the date of handing over of site. The contractor is advised to strictly go through drawings before quoting for each toilet. No extra payments shall be entertained.																
	The above work include all fittings excluding, Floor Tiles, Wall Tiles, False Ceiling, Electrical fittings, Doors, Windos, Grill, Granite sill, Granite/Marble Wash Basin Platform only. This work has be done using Polyethelene-Aluminium-polyethelene (PE-AL-PE) Composite pressure pipes conforming to IS - 15450 only.																
A)	Complete Gents & Ladies Toilet, in Worker Rest Room Building as shown in drawing no.SCEPL/0212/441/RCC-3/WD-5 Complete, Which includes, Bathroom, W.C., Urinal, Washbasin, & Etc.	**1**	**NO**	**1,62,436**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
B)	Complete Toilet in Officers Common Toilet & One attached toilet as shown in drawing no.SCEPL/0212/441/RCC-3/WD-6 Complete with all Acessoires.	**1**	**NO**	**95,677**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
C)	Complete Gents Toilet in Main Gate & Security Block as shown in drawing no. SCEPL / 0212 / 441 / RCC-2 / WD-1 Complete, Which includes, W.C.,Washbasin, & Etc.	**1**	**NO**	**35,267**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
CONCEALED INTERNAL: WATER SUPPLY PIPES																
48	Providing and fixing Chlorinated Polycinyl Chloride (CPVC) pipes, having thermal stability for hot & cold water supply including all CPVC plain & barss threaded fittings i/c fixing the pipe with clamps one step CPVC solvent cement and the cost of cutting chases and making good the same including testing of joints complete as per direction of Engineer in charge.															
	The work also includes for Concealed work including cutting chases and making good the wall etc.																

A)	15 mm nominal bore	**22**	**RM**	**227**	1	0	1	**0**	1	1	2	**2**	1	1	3	**3**
B)	25 mm nominal bore	**12**	**RM**	**325**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
C)	32 mm nominal bore	**35**	**RM**	**405**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
EXTERNAL: WATER SUPPLY PIPES																
49	Providing and fixing Chlorinated Polycinyl Chloride (CPVC) pipes, having thermal stability for hot & cold water supply including all CPVC plain & barss threaded fittings this includes jointings of pipes & fittings with one step CPVC solvent cement, trenching, refilling & testing of joints complete as per direction of Engineer in charge.															
A)	15 mm nominal bore	**89**	**RM**	**136**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
B)	25 mm nominal bore	**56**	**RM**	**212**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
C)	32 mm nominal bore	**90**	**RM**	**271**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
D)	40 mm nominal bore	**12**	**RM**	**373**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
E)	50 mm nominal bore	**126**	**RM**	**583**	1	1	3	**3**	1	1	2	**2**	1	0	1	**0**
50	Providing and fixing heavy GUNMETAL FULLWAY VALVE with C.I. wheel of approved quality (screwed end)															
A)	50 mm nominal bore	**2**	**NO**	**845**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
B)	40 mm nominal bore	**1**	**NO**	**584**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
C)	25 mm nominal bore	**1**	**NO**	**418**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
STONEWARE PIPE																
51	Providing, laying and jointing glazed stoneware pipes of grade A with stiff mixture of cement mortar in 1:1 proportion including testing the joints. The rate shall include excavation upto a depth of 1.5mtr. including backfilling the same, consolidating, ramming, watering, etc. complete and disposing off the surplus earth as directed within the plot, laying cement concrete 1:4:8 as bedding at the joints upto the haunches of S.W. pipe having a bed thickness of 15cm mimimum,curing, etc. complete.															
A)	150 mm diameter	**77**	**RM**	**222**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
DRAINAGE WORKS																

52	Constructing brick masonry chamber for undeground C.I. inspection chamber and bends with 50 class designation brick in cement 1:4 (1 cement : 4 coasre sand) C.I. cover with frame (light duty) 455x610 mm internal dimensions, totle weight of cover with frame to be not less than 38 kg (weight of cover 23 kg and weight of frame 15 kg) R.C.C. top slab with 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) foundation concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) and making necessary channel in cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 40 mm nominal size), inside plastering 12 mm thick eith cement mortar 1:3 (1 cement : 3 coarse sand) finished smooth with a floating coat of neat cement on and bed concrete etc. complete as per standard design :															
A)	Insided dimensions 455x610 mm and 45 cm deep for single pipe line :With F.P.S. bricks	**2**	**NO**	**7,163**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
B)	Insided dimensions 500x700 mm and 45 cm deep for pipe line with one or two inlets :With F.P.S. bricks	**1**	**NO**	**8,047**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
C)	Insided dimensions 600x850 mm and 45 cm deep for pipe line with three or more inlets : With F.P.S. bricks	**1**	**NO**	**9,205**	0	1	1	**0**	1	1	2	**2**	1	1	3	**3**
53	Constructing brick masonry manhole in cement 1:4 (1 cement : 4 coasre sand) R.C.C. top slab with 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) foundation concrete 1:4:8 mix (1 cement : 4 coarse sand : 8 graded stone aggregate 40 mm nominal size) inside plastering 12 mm thick wiyh cement mortar 1:3 (1 cement : 3 coarse sand) finished with floating coat of neat cement and making channels in cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregated 20 nominal size) finished with a floating coat of neat cement complete as per standard design :															
	Inside size 120x90 cm and 90 cm deep including C.I. cover with frame (medium duty) 500 mm internal diametre total weight of cover and frame to be not less than 116 kg (weight of cover 58 kg and weight of frame 58 kg) :															
	With Sewer bricks conforming to IS : 4885	**3**	**NO**	**18,389**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
SEPTIC TANK																

54	Constructing brick masonry septic tank for 100 users and soakpit 1.50 mt dia including necessary excavtion, laying CC 1:5:10 in foundation, brick masonry walls in CM 1:5, finishing inside bottom with CC 1:2:4, flooring 50 mm thk. plastering the side walls internally with CM 1:3 20 mm thk. mixed with water proof compound, supplying and laying 100 mm dia SW pipe, toes, bends from septic tank to soak pit including supplying and fixing 75 mm dia CI pipe (vent pipe) with cowl, provision of 2 no. of CI heavy duty sump covers 600 mm dia and 25 kg by weight (each) and providing RCC slab on top, including construction of 2 no. inspection chambers 450 x 450 mm size (inside) as to the required depth for both inlet and outlet of septic tank with 75 mm thk. The septic tank and allied facilities shall be complete in all respects as per enclosed drawings.															
A	Same as above but for brick masonry septic tank and soak pit for 50 users .	**1**	**EA CH**	**51,763**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
OVER HEAD SINTEX WATER TANK																
55	Providing and fixing in position standard one piece readymade water storage tank made of L.D.P.E including hoisting,fixing in position, inlet, outlet, overflow, drain connections, etc. complete in all respect, ofspecified sizes.															
A)	2000 Lt Capacity	**4**	**EA CH**	**21,109**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
STAINLESS STEEL SINK																
56	Providing and fixing stainless steel sink with drain board with CI brackets, stainless steel baskets, waste and plug 40mm CP brass bottle traps with pipe to wall and CP flanges, the rubber adopter for waste connections complete, including cutting and making good the surface. Single sink with overall size 510x1040 bowl depth 178 mm. with drain board or nearest commercial size with CP fittings.	**1**	**NO**	**6,178**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
WATER COOLER																
57	Providing & fixing S.S.WATER COOLER with necessary stand in approved brand, colour and shade as per site instructions. Necessary inlet and outlet connections, drain connections shall also be included as part of works to be completed.	**3**	**NO**	**14,002**	1	0	1	**0**	1	1	2	**2**	1	1	3	**3**
WATER PURIFIER																
58	Providing & fixing "EUREKA FORBES "AQUAGUARD BOOSTER " water purifier including necessary installation and commissioning.	**3**	**NO**	**10,269**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**

MISCELLANEOUS WORKS																
59	Providing & Fixing using RAMCO Make HILUX 8MM Calcium Silicate Suspended False Ceiling with 0.55mm Thick Hilux Make G.I. Ceiling Section 600 C.C Intermediate Section 1200 C.C Suspender Parameter Section Ceiling Section & Intermediate Sections Connected with Connecting Clip & Suspended Ceiling Angle Suspended with 2 in 1 Fastner,) screwing on board 300 X 450 self Tapping Screw having Philips head with under head cutter Size 7G X 25mm, joint finish with special Hilux Jointing Compound and 48mm wide self adhesive fiber tape in Proper line-N-level including making necessary provision for light, AC fitting cutout, etc. complete as per manufacturer's specification and as approved by EIC.	**200**	**SQ M**	**1,347**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
MS GRILL																
60	Providing and fixing MS grilles using MS flats of size 20 mm X 6 mm of approved design including fixing/ grouting the grilles using MS hold fasts in CC 1:2:4 with masonry, painting with 2 coat of synthetic enamal paint over a coat of zinc phosphate primer etc. complete. (The weight of MS grille taken as 18 Kg per Sqm)	**110**	**SQ M**	**1,027**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
RAIN WATER PIPES																
61	Providing and fixing on wall/Cladding/Structural steel face Unplasticised rigid PVC (4 Kgf /sq.cm) water pipes including cutting and jointing as per manufacturers specification, fixing with MS holder bat clamp including all specials etc. necessary M.S. holder bat clamps embedded including all specials bottom shoes, bends, etc., necessary cutting in floor and walls wherever required and making good the same including providing and fabricating M.S. pipe sleeve of suitable diametre to match the inlet mouth of rain water pipe providing and applying two coats of approved paint to match the shade of the wall/Cladding/Structural steel etc. complete. Confirming to IS Code for Pipes: IS 13592 & For Joints: IS 5382.															
A	100 mm diameter	**103 2**	**RM**	**236**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
WET MIX MACADAM.																

62	Providing, Laying, spreading & compacting specified graded stone aggregate to Wet Mix Macadam in layer of 75/100/150mm thk compacted including premixing the material with water to O.M.C. in mechanical mixer (Pug Mill) carrying of mix material by tipper to site and laying with paver finisher on prepared Existing Subbase and compacting with vibrating tandem roller to achieve the density of 98% of M.D.D including all material, Labour, Machinery with all leads & lifts etc. complete as directed ny E.I.C.	**603**	**CU M**	**586**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
STONE MASONARY																	
63	Random rubble masonry with hard stone in foundation,plinth, floor, wall, retaining & etc upto any height including leveling up with cement concrete 1:6:12 (1 cement : 6 coarse sand : 12 graded stone aggregate 20 mm nominal size). with :Cement mortar 1:6 (1 cement : 6 coarse sand) including Pointing with Cement mortar of 1:4. Complete, including keystoones & etc as directed by E.I.C.	**235**	**CU M**	**3,232**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
M.S. GATE																	
64	Supply, fabricating, welding for MS Gate of size 6 m wide and 3 m height in two leaves, using MS Pipe 65 mm dia B Class, 2 mm MS Sheet, fixing of same in RCC Columns, grouting of MS Flat as rail for movement of Gate on RCC Road below, painting of Gates with two coats of zinc phosphate primer and two coats of aluminium paint as per drawing enclosed.	**36**	**SQ M**	**5,921**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
65	Supply, fabricating, welding for MS Wicket Gate of size 1.2 m wide and 1.8 m height, using MS Pipe 50 mm dia B Class, 2 mm MS Sheet, 25 mm square mesh 10 gauge, fixing of same in RCC Columns, painting of Gates with two coats of zinc phosphate primer and two coats of aluminium paint as per drawing.	**3**	**SQ M**	**10,864**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
66	Welded steel wire fabric fencing with posts of specified material and of standard design placed and embedded in cement concrete blocks 45x45x60 cm of mix 1:5:10 (1 cement :5 fine sand :10 graded stone aggregate 40 mm nominal size) every 15th post, last but one end post and corner post shall be strutted on both sides and end post on one side only and struts embedded in cement concrete blocks 70x45x50cm of the same mix, provided with welded steel wire fabric fixed between the posts fitted and fixed with G.I. staples on wooden plugs or tied to 6 mm bar nibs with G.I. binding wire (cost of posts, earth work in excavation and concrete to be paid for separately). The above work also includes the cost of painting.	**566**	**RM**	**456**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**

67	Supplying and laying hard clean stone aggregate of 93 mm. - 43 mm. size for Water Bound Macadam sub-base course, including stacking the same by the side of the road with all lift and lead, sorting out, spreading to template, for a total thickness of 100 mm. watering, thoroughly rolled with 10 T Road Roller to form 75 mm, Over that Suplying & Laying stone aggregate of 93 mm. - 43 mm. size for Water Bound Macadam sub-base course, including stacking the same by the side of the road with all lift and lead, sorting out, spreading to template, for a total thickness of 100 mm. watering, thoroughly rolled with 10 T Road Roller to form 75 mm & finally Supplying and laying hard clean stone aggregate of 53 mm. - 22.4 mm. size for Water Bound Macadam sub-base course, including stacking the same by the side of the road with all lift and lead, sorting out, spreading to template, for a total thickness of 75 mm. watering, thoroughly rolled with 10 T Road Roller to form 75 mm compacted, all the above compacted thickness to proper level, grade and camber including blinding the surface with murrum, watering, rolling etc. as specified and directed.	**1005**	**SQM**	**1,485**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
68	Provinding and laying non - pressure NP2 class (light duty) R.C.C. pipes with collars jointed with stiff mixture of cement in the proportion of 1:2 (1 cement : 2 fine sand) including testing of joints etc. complete with all lead/ lift/ materials etc. Note: The civil works like excavation, PCC etc. will be measured and paid under respective items.															
A	150 mm diameter	**10**	**RM**	**297**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
B	300 mm diameter	**52**	**RM**	**378**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
C	600 mm diameter	**10**	**RM**	**1,308**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
D	900 mm diameter	**10**	**RM**	**2,066**	1	0	1	**0**	1	1	2	**2**	1	1	3	**3**
E	1000 mm diameter	**10**	**RM**	**2,544**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
F	1200 mm diameter	**10**	**RM**	**3,227**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
BITUMINUS MACADUM																

69	Providing and laying Dense bituminous macadam on prepared surface with specified graded crused stone aggregate for profle corrective base/binding course including loading of aggregate with FE loader and hot mixing jof stone aggregate, filler and bitumen in hot mix plant, transporting the mixed material by tippers to paver and laying the mixed material with paver finisher fitted with electronic sensing device to the required level and grade and rolling by road roller as per MORTH specification, to achieve the desired density, including the cost of primer/tack coat. 75mm average compacted thicknesswith bitumen of 60/70 grade @5% (percentage by weight of total mix) and lime filler @2% (percentage by weight of aggregate).	**302**	**CU M**	**10,323**	1	1	2	**2**	1	0	1	**0**	1	1	3	**3**
70	Providing and laying dense bituminous concrete on prepared surface with specified graded stone aggregate for wearing course including loading of aggregate with FE loader and hot mixing of bitumen with filler and stone aggregate in hot mix plant, transporting the mixed material by tippers to paver and laying the mixed material with mechanical paver finisher fitted with electronic sensing device to the required level and grade and rolling by road roller as per MORTH specification, to achieve the desired density and compaction including the cost of primer/tack coat. 25mmcompacted thickness with bitumen of grade CRMB - 60 @ 5.5% and lime @ 3% (percentage by weight of total mix)	**101**	**CU M**	**9,023**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
ELECTRICAL:																
SITC = SUPPLY,INSTALLATION,TESTING AND COMMISSIONING.																
71	S.I.T.C.of Main Panel in meter room comprising of 1no 300 amps 4 pole mccb as incommer , metering, copper busbar 250 amps , outgoings 1 no 125 amps 4 pole mccb , 1 no 63 amps 4 pole mccb, 32 amps 4 pole mccbs 5 nos , 35 ka complete as per IS specifications from CPRI manufacturers.	**1**	**Nos.**	**68,435**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
72	S.I.T.C of following MCCBs as main swithes in warehouse, adm block, security block , external electricals.															
a	125 amps 4 pole mccb 35 ka as main switch in ware house for power	**1**	**Nos.**	**6,670**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
b	63 amps 4 pole mcb as main switch in ware house for lighting, Adm bldg power and lighting.	**2**	**Nos.**	**4,300**	1	0	1	**0**	1	1	3	**3**	1	1	2	**2**
c	32 amps 4 pole mcb as main switch in ADM block,security block and ecternal common services.	**2**	**Nos.**	**1,186**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
MCB DISTRIBUTION BOARD																

73	S.I.T.C. of 12 Way TPN DB, LDB comprising of 1 no 63 amps 4 pole 100 mili amps RCCB as incommer & outgoings 6/10 amps SPMCBs 36 nos ,double door distribution board for ware house lighting.	**1**	**Nos.**	**13,595**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
74	S.I.T.C. of Distribution board manufactured from CPRI approved panel manufacturer comprising of 1 no 125 amps mccb as incommer and outgoings 32 amps sp mcbs 16 nos, 32 amps TPN mcbs 16 nos, and 16 amps SPmcbs 20 nos with double door distribution board for ware house power load.	**1**	**Nos.**	**1,02,213**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
75	S.I.T.C. of 8 way Distribution board , LDB comprising of 63 amps 4 pole 100 mili amps RCCB as incommer and 6/10 amps SPMCBs 12 nos, 20/25 amps SP MCBs 6 nos as outgoings with double door distribution board for ADM lighting and power load.	**1**	**Nos.**	**9,430**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
76	S.I.T.C. of 8 way distribution board for security block and external electrical lighting comprising of 1 no 63 amps 4 pole mili amps RCCB as incommer and 6/10 amps SP MCBs 12nos as outgoings with double door distribution board.	**1**	**Nos.**	**9,430**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
77	SITC of 25 mm flange, 150 mm wide G.I Perforated type cabletray with 14 SWG Sheet complete with fixing hardware such as clambs nutbolt etc.	**1000**	**Mtrs.**	**454**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
78	S.I.T.C. of CRCA Sheet 2mm (14 guage) fabricated cable junction box.complete with all fixing accessoies for connections of cables to light fittings.	**10**	**Sq. mtr**	**1,525**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
Cables & Cable Terminations																
79	2 core x 2.5 Sq.mm. Copper conductor PVC insulated Armoured cable 1.1KV grade.(For light points & 6Amps Sockets)	**8000**	**mtrs**	**107**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
80	3core x 2.5 Sq.mm. Copper conductor PVC insulated Armoured cable 1.1KV grade.(For 16 amps power sockets.)	**600**	**mtrs**	**140**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
81	2 core x 6 Sq.mm. Copper conductor PVC insulated Armoured cable 1.1KV grade.(For 32 amps power points sockets single phase)	**800**	**mtrs**	**182**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
82	4 core x 4 Sq.mm. Copper conductor PVC insulated Armoured cable 1.1KV grade.(For 32 Amps power points sockets 3 phase)	**800**	**mtrs**	**219**	1	0	1	**0**	1	1	3	**3**	1	1	2	**2**
83	4 core x 6 Sq.mm. Copper conductor PVC insulated Armoured cable 1.1KV grade.(For ADM Bldg, Security block, and ecternal electrical services)	**400**	**mtrs**	**291**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
84	4 core x 25 sqmm Copper conductor PVC insulated Armoured cable 1.1 KV grade for Warehouse	**150**	**mtrs**	**981**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
85	4 core x 70 Sq.mm. Aluminium conductor PVC insulated Armoured cable 1.1KV grade.for Power distribution board and main switch for power of	**150**	**mtrs**	**443**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**

	warehouse.															
86	3.5 core x 185 Sq.mm. aluminium conductor PVC insulated Armoured cable 1.1KV grade.(Main Incoming cable)	**200**	**mtrs**	**872**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
87	2 core x 2.5 Sq.mm YFY Cable glands.	**242**	**Nos.**	**28**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
88	2 core x 6 YFY Cable glands.	**28**	**Nos.**	**33**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
89	3 core x 2.5 Sq.mm YFY Cable glands.	**21**	**Nos.**	**33**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
90	4 core x 4 Sq.mm YFY Cable glands.	**32**	**Nos.**	**33**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
91	4 core x 50 Sq.mm YFY Cable glands.	**5**	**Nos.**	**81**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
92	4 core x 70 Sq.mm YFY Cable glands.	**2**	**Nos.**	**90**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
93	3.5 core x 185 Sq.mm AYFY Cable glands.	**7**	**Nos.**	**172**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
94	2 core x 2.5 Sq.mm YFY Cable lugs.	**423**	**Nos.**	**11**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
95	2 core x 6 sqmm YFY Cable Lugs.	**54**	**Nos.**	**11**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
96	3 core x 2.5 Sq.mm YFY Cable lugs.	**54**	**Nos.**	**11**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
97	4 core x 4 Sq.mm YFY Cable lugs.	**54**	**Nos.**	**11**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
98	4 core x 50 Sq.mm YFY Cable Lugs.	**8**	**Nos.**	**32**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
99	4 core x 70 Sq.mm YFY Cable Lugs.	**8**	**Nos.**	**48**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
100	3.5 core x 185 Sq.mm AYFY Cable lugs.	**8**	**Nos.**	**159**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
	Sockets ans switches.															
101	S.I.T.C. of 32 Amps 3 Phase TPN Socket with MCB box, complete MDS make Legrand cat.no.607851 with TP MCB Legrand cat.no 603305.complte with fixing on angle frame work with fixing accessories.	**16**	**Nos.**	**5,037**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
102	S.I.T.C. of 40 Amps 4 pole MCB in Enclosure MDS Legrand make.	**3**	**Nos.**	**1,753**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**

103	S.I.T.C. OF 6 amps 2 nos socket and switches, 16 amps switch and socket 1 no, 1 no telephone jack 2 pin, 1 no data computer socket to be fixed of FRLS, water proof , fire retardent boxes .	**6**	**Nos.**	**1,672**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
104	same as item no 33 but no Data socket.	**13**	**Nos.**	**1,510**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
105	same as item no 33 but no telephone point	**1**	**Nos.**	**1,502**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
106	S.I.T.C . Of Timer L& T make in enclosure for street light poles.	**1**	**Nos.**	**3,513**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**
107	S.I.T.C of 6 amps socket and switch on switchbards in ADM Bldg, Anchor roma make moduler.	**8**	**Nos.**	**447**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
108	S.I.T.C of 1 no 32 amps single phase power socket and 1 no 32 amps 3 phase power socket MDS make with MCBs mounted on weather proof and FRLS box complete with all accessories.	**28**	**Nos.**	**6,954**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
	Fire alarm system and Tag block.															
109	S.I.T.C of Telephone junction box Krone type with 40 pair tag block.	**1**	**Nos.**	**859**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
110	S.I.T.C of Fire panel conventional type 2 zone complete with battery backup as per ISI specifications.	**1**	**Nos.**	**12,247**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
111	S.I.T.C. of smoke detector appolo make .	**6**	**Nos.**	**1,599**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
112	S.I.T.C. of Hooter.	**1**	**Nos.**	**475**	1	1	2	**2**	0	1	1	**0**	1	1	3	**3**
113	S.I.T.C. of Manual call point / break glass.	**6**	**Nos.**	**420**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
114	S.I.T.C. of fire extinguishers wall mounted, 5 KG.	**16**	**Nos.**	**2,076**	1	1	1	**1**	1	1	2	**2**	1	1	3	**3**
115	S.I.T.C. of 2 core x 1.5 sqmm copper conductor armoured pvc insulated cable 1.1 kv grade complete with connections.	**400**	**mtrs.**	**48**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
Light Fittings and fans.																
116	S.I.T.C of 2 x 18 watts CFL light fittings complete with lamps.	**68**	**Nos.**	**997**	1	1	1	**1**	1	1	3	**3**	1	1	2	**2**
117	S.I.T.C of 1 X 36 Watts CFL water proof, weather proof light fittings with tube complete.	**8**	**Nos.**	**961**	1	1	2	**2**	1	1	1	**1**	1	1	3	**3**
118	S.I.T.C of Industrial highbay 250 watts light fittings with polycarbonate reflector complete with lamp.	**91**	**Nos.**	**11,306**	1	1	2	**2**	1	1	3	**3**	1	1	1	**1**
119	S.I.T.C. of flood light fitting 250 watts complete with lamp.	**4**	**Nos.**	**3,397**	1	1	3	**3**	1	1	2	**2**	1	1	1	**1**

120	S.I.T.C of 150 watts metal halide street light fittings complete with lamp.	39	Nos.	2,853	1	1	1	1	1	1	3	3	1	1	2	2
121	S.I.T.C. of 2 nos 18 watts CFL lamp.	66	Nos.	270	1	1	2	2	1	1	3	3	1	1	1	1
122	S.I.T.C of Ceiling fans 48 inches .	8	Nos.	1,325	1	1	2	2	1	1	3	3	1	1	1	1
123	S.I.T.C. of wall fan 600mm / 24 inches dia industrial complete with all accessories.	12	Nos.	5,803	1	1	2	2	1	1	3	3	1	1	1	1
124	S.I.T.C of Exhaust fans 12 inches complete with all fixing accessories.	12	Nos.	1,272	1	1	1	1	1	1	2	2	1	1	3	3
125	S.I.T.C of M.S. Tubular poles duely painted with redoxide, silver paint complete as per IS specifications ,	19	Nos.	9,284	1	1	1	1	1	1	3	3	1	1	2	2
Earthing																
	Supply, laying, connection & testing bare earthing conductor for inter-connecting the earthing stations and various equipment in built up trenches, walls/ceiling, buried in ground generally as specified and shown on the drawing complete with all accessories and S.I.T.C of earthing stations															
126	S.I.T.C. of earthing stations complete as per ISI specifications with G.I. earth plate 600x600x 6 mm with	2	Nos	1,788	1	1	1	1	1	1	2	2	1	1	3	3
127	50 x 10 G.I Strips	1000	Kg.	80	1	1	3	3	1	1	2	2	1	1	1	1
128	25 x 3 G.I. Strip	200	Kg.	80	1	1	1	1	1	1	3	3	1	1	2	2
	BVj Score				158	151	241	223	163	161	414	410	163	160	329	324

LIST OF PUBLICATIONS

International Journals

1. "Practical Approach to Construction Industry using Best Value and Six Sigma Techniques", Journal of Construction Engineering and Management, ASCE (Communicated – June, 2017).

National Journals

1. "An application of Best value system in Construction Industry: A State of Art", Nicmar-Journal of Construction Management, Nicmar Publications (Communicated – March, 2017).

ACKNOWLEDGEMENT

I am thankful to guide Dr. R. B. Magar for his aspiring guidance, invaluable constructive criticism and advice during the project work. I am sincerely grateful to him for sharing his truthful and illuminating views on a number of issues related to the project.

I am thankful to Dr. Abdul Razak Honnutagi, Director, AIKTC, for providing me the required infrastructure, timely guidance and administrative support.

I am highly thankful to all faculties of M.E. (CEM), Prof. Parker, Prof. Mahajan, Prof. Gawade, Prof. Jadhav, Prof. Dada Patil for their timely support and encouragement throughout the course.

I extend my thanks giving to Mr. Ashish Srivastava, Managing Director, Structech Consulting Engineers (India) Pvt. Ltd. and Mr. Rohit Ghughare, Project Manager, Rhythm Realty, for their extensive support in data collection required for the research.

I would like thank Mr. Afroz Khan, Class representative, M. E. (CEM), for his extensive help and timely updates throughout the course completion. Also I would thank my collegues Prof. Kothari and Prof. Chorghe, for their motivational support throughout the course.

I would like to take this opportunity to thank all my classmates for their timely help during the course of completion of this report.

Last but not the least, I thank my dearest parents, Mr. Mangesh D. Rath and Mrs. Rashmi M. Rath who provided me the required moral support to reach out upto my goals; and almighty god for his showers of blessings.