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# Investigation on Optimization of Time, Cost and Quality in Construction Project

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***Abstract: Time, cost, and quality are three major competitive objectives of every construction industry. The aim of project control is to ensure the projects finish on time, within budget and achieving best quality. Time and cost are among the important aspects considered for every construction project. Time, with its associated costs, is vitally important for each participant in the construction process including the owner, engineers and contractors.***
***Keywords: Time, Cost, Quality, Owner, Contractors.***

## I. INTRODUCTION

There is a constant rise in the use of innovative contract methods which provide incentives for maximizing quality. There is an increasing pressure to improve the project performance due to the innovative contracting methods which necessitate developing models incorporating quality along with time and cost.

It is always a complex and challenging task for a contractor, to choose a correct bid which satisfies the time, cost and quality requirements of a project. The purpose of create balance among time, cost, and quality is to make the best level of customers satisfaction and end users and to obtain the most optimal level of value for organization.

## II. LITERATURE REVIEW

*1)* Jesper Kranker Larsen et al., (2015) conducted studies Factors Affecting Schedule Delay, Cost Overrun, and Quality Level in Public Construction Projects. As a result of the loss of financial resources and the need to optimize projects, academics, politicians, and the construction industry have become increasingly aware of the challenges presented by the frequent time and cost overruns and reduced quality of construction projects. The main conclusion of this research is that project schedule, budget, and quality level are affected in significantly different ways. Therefore, a project manager cannot handle such critical issues by focusing only on schedule or budget complications; nor can he or she assume that time, cost, and quality are equally affected.

*2)* Lianying Zhang et al., (2014) determines Solution to the Time-Cost-Quality Trade-off Problem in Construction Projects Based on Immune Genetic Particle Swarm Optimization. The importance of time-cost-quality trade-off in construction projects has been widely recognized by the construction industry. Optimization results proved the practicability and validity of the model. We offer several Pareto solutions for a decision-maker to choose from in accordance with their expertise and project considerations.

*3)* S. Shanmugapriya et al., (2013) studied about the significant factors causing Time overruns and Cost overruns in Indian construction projects. The data from the questionnaire was analyzed statistically. Relative important index method was used to found out the most significant factors affecting Time and Cost overruns. The result accomplished from the survey revealed that

*a)* *The Major Causes For Time Overruns Are*

*i)* Material market rate
*ii)* Contract modification and
*iii)* High level of quality requirement

*b)* *The Major Causes For Cost Overruns Are*

*i)* High transportation cost
*ii)* Change in material specification and
*iii)* Escalation of materials price.

*4)* Ghaleb J. Sweis et al., (2013) studied about Factors Affecting Time Overruns in Public Construction Projects. Time overrun is a very frequent phenomenon and is almost associated with nearly all projects in the construction industry. The top ten factors causing time overruns in construction projects were identified and treated using Principal Component and Factor Analysis (PCFA). After conducting the analysis on both the secondary and primary data, results showed agreement only on one cause, weather conditions.

*5)* Aftab Hameed Memon et al., (2012) systematically analyzes the time and cost performance of construction projects in Malaysia using structured questionnaire survey. The findings of study revealed that 92% of construction projects were overrun and only 8% of project could achieve completion within contract duration. The major contributors of this poor performance include

*a)* Design and documentation issues

*b)* Financial resource management and project management

*c)* Contract administration issues.

*6)* Kenny Wong et al., (2012) have made a study on the factors affecting construction time. Delays are major problems in the construction industry. Delays can lead to many negative effects such as cost overruns, and is of high concern to those who are involved in the construction industry. This study was set to identify the major causes of delays in the Western Australian construction industry. Based on the data received, albeit limited, the top ten most important causes identified were: (1) Shortage of skills; (2) Financial difficulties; (3) Shortage of labour; (4) Unrealistic deadlines for project completion; (5) Unforeseen ground conditions; (6) Poor organization of the contractor or consultant; (7) Poor communication; (8) Underestimation of time of completion; (9) low speed of decision; and (10) Design errors made by designers.

*7)* Souma M et al., (2010) have studied about the statistical analysis on the cost and duration of public building projects. A probabilistic model is proposed to predict the risk effects on time and cost of public building projects. The research goal is to utilize a real history data in estimating project cost and duration.. The regression model results were validated by estimating the prediction error in percent and through conducting out-of-sample tests. In conclusion, the models were validated at a probability of 95%, at which the proposed models predict the project cost and duration at an error margin of 0.035% of the actual cost and time.

*8)* Sathya narayanan.A et al., (2010) have made a paper on multi-objective optimization of construction project time-cost-quality trade-off using differential evolution algorithm. Time and cost are among the important aspects considered for every construction project. Many research approaches have been followed to model time-cost relationship. Two case studies are analyzed and the results obtained compared with the existing approaches to test the applicability and efficiency of the algorithm. It is evident from the results that the differential evolution algorithm performs efficiently in locating the optimal solution with minimum function evaluation.

*9)* Frimpong Y et al., (2003) indentifies the causes of delay and cost overruns in construction of ground water projects. The study is based on data relating to groundwater construction projects in Ghana. There are many factors that can cause delay and cost overruns in groundwater drilling projects.The data indicated that 75% of the projects exceeded the original project schedule and cost whereas only 25% were completed within the budget and on time. Based on this study, the researcher gives the following recommendations to improve the performance of project,

*a)* To provide the appropriate funding based on work done.

*b)* To provide continuous work-training programs for personnel in the industry to update their knowledge.

*c)* Effective and efficient material procurement systems should be established within projects.

## III.METHODOLOGY

The desired objective can be obtained by sequencing the flow of work into a typical methodology.

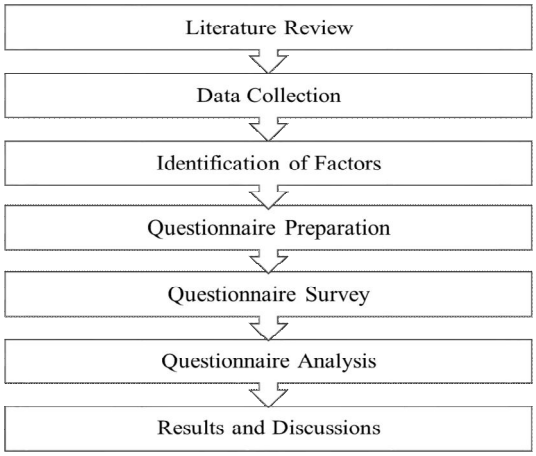



Fig. 1 Methodology Flow Chart

## IV. FACTORS IDENTIFICATION

From several reviews of literature the factors affecting time, cost and quality in construction project are identified. These factors have been mainly grouped into two major divisions such as time factors, cost factors and quality factors.

### A. *Time Related Factors*

#### 1) *Project Conditions*

The project conditions that affect time in construction are

*a)* Project size and location
*b)* Availability of equipments and materials
*c)* Poor planning and scheduling of the project
*d)* Presence of unskilled labors
*e)* Risk and uncertainty associated with projects

#### 2) *Management conditions*

The management conditions that affect time in construction are

*a)* Slow decision making from owner
*b)* Delay in progress payments by the owner
*c)* Owner/ engineer interference in the project
*d)* Too many change orders from owner
*e)* High level of quality requirements

#### 3) *Environmental Conditions*

The environmental conditions that affect time in construction are

*a)* Severe weather conditions on the job site
*b)* Number of construction activities going at the same time
*c)* Soil condition in the site cause delay in the construction
*d)* Claims and disputes in the job site
*e)* Labor strike will cause delay in the activity and schedule

#### 4) *Equipment's and materials conditions*

The equipment's and materials conditions that affect time in construction are

*a)* Equipment conditions greatly affects the productivity
*b)* Frequent equipment breakdowns
*c)* Modification in material specifications
*d)* Delay in materials delivery
*e)* Dependency on imported materials

### B. *Cost Related Factors*

#### 1) *Market requirements*

The market requirements that affect cost in construction are

*a)* Instability of market conditions
*b)* Risk in fluctuation of material prices
*c)* Variation in taxation for various resources
*d)* Number of bidders on competitive projects
*e)* Risk in fluctuation of labor prices

#### 2) *Technological requirements*

The Technological requirements that affect cost in construction are

*a)* Frequent change in design
*b)* Change in design specifications during construction
*c)* Construction method and technology used in project
*d)* Error in estimation
*e)* Off/on-site operations sequence and limitations

*3) Resources Requirements*

The Resources requirements that affect cost in construction are

*a)* Resource wastage on site during construction
*b)* Delay in material procurement
*c)* Labor productivity
*d)* Shortage of skilled labors
*e)* Demand of equipment and materials

*4) Contractor related factors*

The Contractor related factors that affect cost in construction are

*a)* Inappropriate construction methods
*b)* Client requirements on quality
*c)* Incorrect planning and scheduling by contractors
*d)* Additional work in site
*e)* Mistakes and reworks in construction

*C. Quality Related Factors*

*1) Contractor related factors*

The Contractor related factors that affect quality in construction are

*a)* Lack of management commitment to continual quality improvement
*b)* Lack of management leadership and contractor involvement in quality
*c)* Poor financial control on site
*d)* Lack of labor productivity
*e)* Contractor's poor site management and supervision

*2) Consultant related factors*

The Consultant related factors that affect quality in construction are

*a)* Poor information and communication channels
*b)* Lack of coordination between designers and contractors
*c)* Too many change orders in the work
*d)* Poor quality of design and specification
*e)* Inefficient team work among stakeholders

*3) Equipment related factors*

The Equipment related factors that affect quality in construction are

*a)* Poor quality of equipment's and raw materials
*b)* Lack of advanced technology in construction
*c)* Poor utilization of equipment's and materials
*d)* Construction method and technology
*e)* Late delivery of construction materials and equipment's

*4) Technology related factors*

The Technology related factors that affect quality in construction are

*a)* Poor planning and scheduling techniques
*b)* Lack of technical and professional expertise to perform task
*c)* Mistakes during construction and rework
*d)* Construction quality control meetings and training
*e)* Lack of effective monitoring and feedback by the project team members

## V. QUESTIONNAIRE OUTLINE

The questionnaires are all classified into 2 sections:

*1) Section A:* Company and respondent profile
*2) Section B*

*a)* Time related factors in construction project
*b)* Cost related factors in construction project
*c)* Quality related factors in construction project

Based on the literatures and factors considered, a Questionnaire was designed as a measurement tool to control time, cost and quality in construction. The sixty factors were adapted to measure time, cost and quality in construction project.

Also the respondents were asked to rate their level of argument according to 5 point scale (Likert's scale) according to level of contributing

(1) = Strongly Disagree (2) = Disagree (3) = Moderate
(4) = Agree (5) = Strongly Agree

## VI. DATA ANALYSIS

In this study, primary data is obtained using structured questionnaires. The collected data is to be analyzed using SPSS.

### *A. Time Related Factors*

The average indices for all factors are calculated. Frequency analyses are done for all factors and main factors which affecting time is given below.

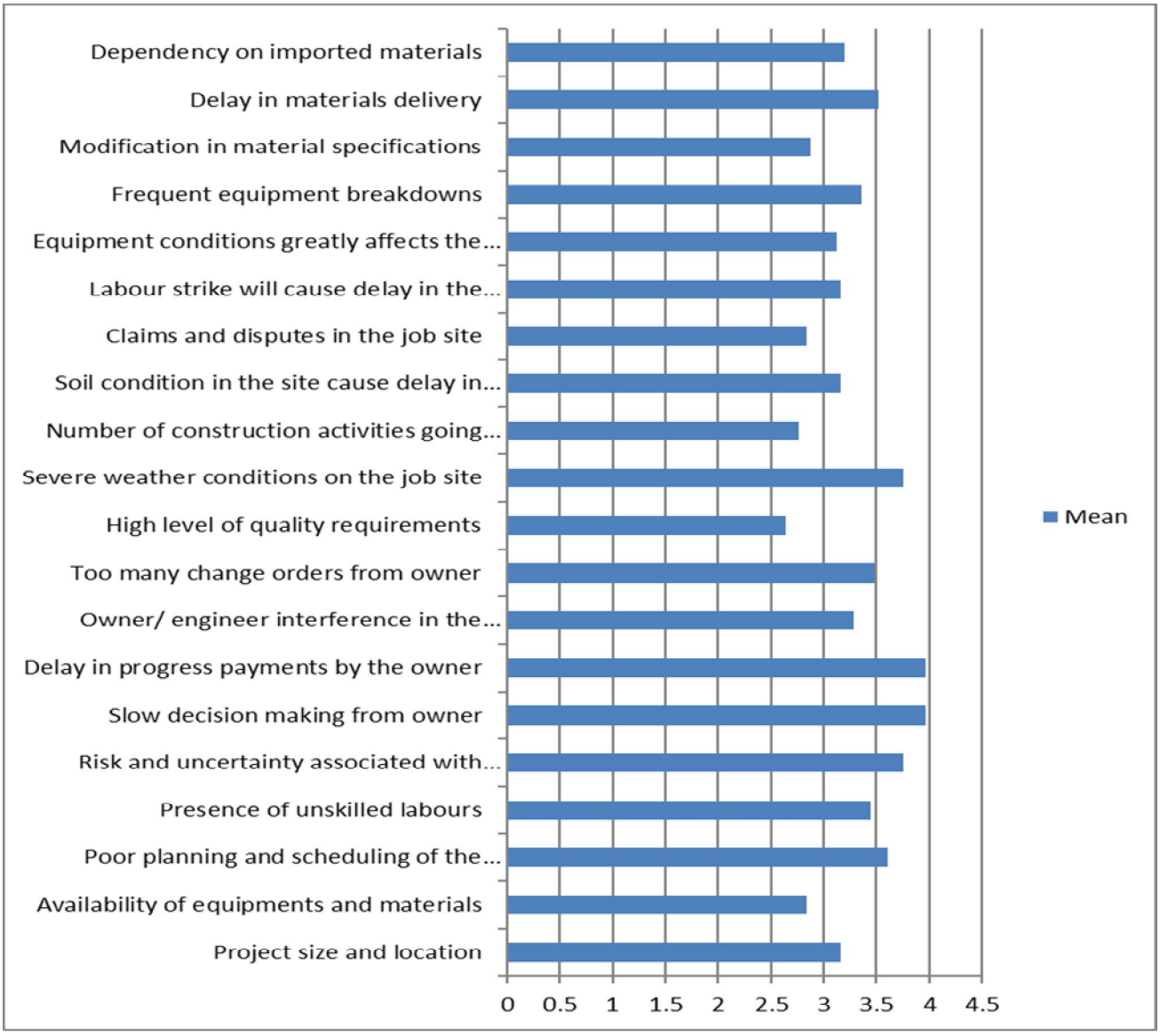



Fig. 2. Average index for time related factors

*B. Cost Related Factors*

The average indices for all factors are calculated. Frequency analyses are done for all factors and main factors which affecting cost are given below.

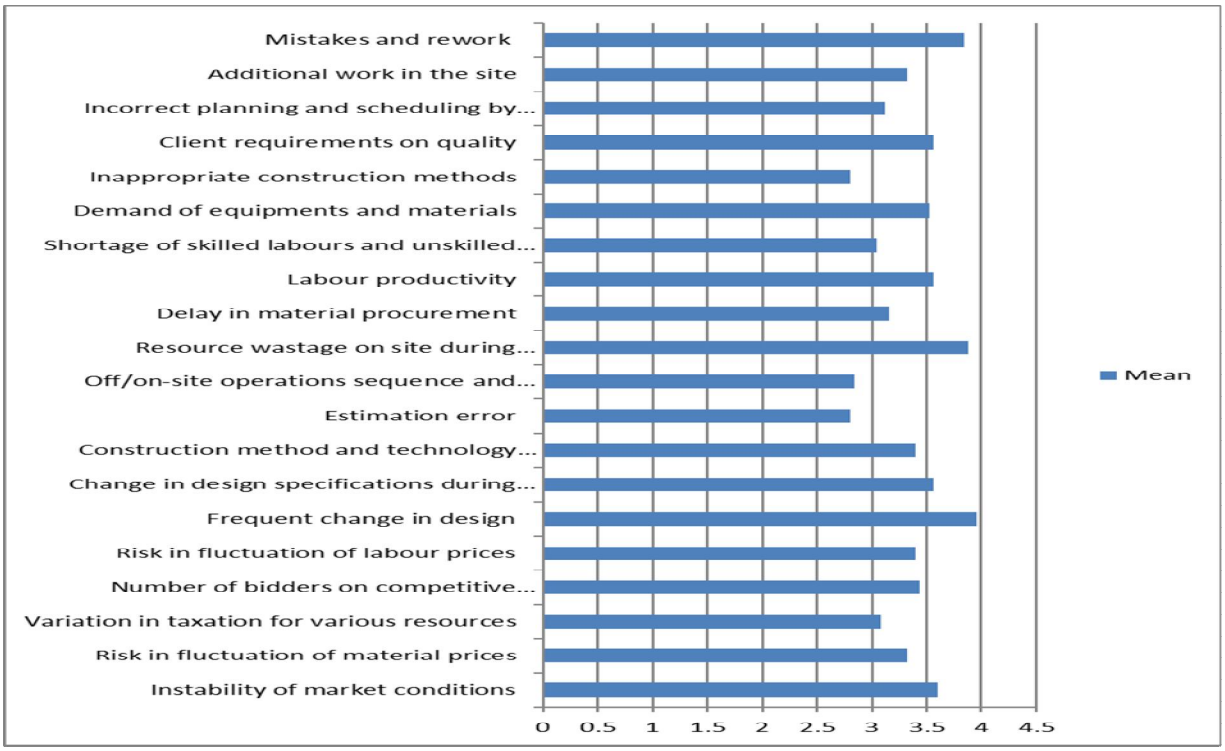
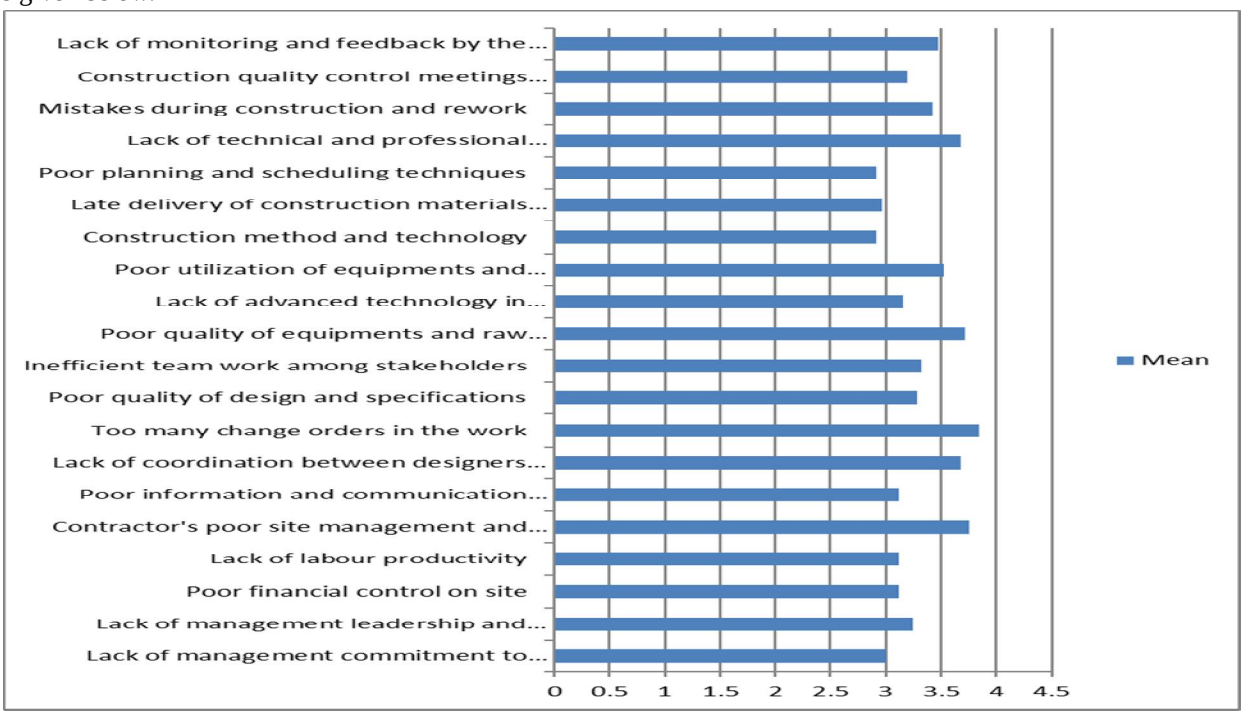



Fig. 3. Average index for cost related factors

*C. Quality Related Factors*

The average indices for all factors are calculated. Frequency analyses are done for all factors and main factors which affecting quality is given below.




Fig,.4. Average index for quality related factors

## VII. RESULTS AND DISCUSSIONS

The analysis shows that in most of the Indian construction firm's time, cost and quality affected by many factors. Ranking of factors affecting time, cost and quality were identified and discussed as follows. Factors are analysed by using SPSS software and they are ranked based on mean value and suggestions are given in order to improve the quality and to finish the project on time within the budget. All factors are ranked according to degree of importance and top five factors affecting time, cost and quality are discussed below. Recommendations are given to rectify factors affecting time cost and quality of the construction project. In this research, a total number of 100 questionnaires were administered and retrieved.

TABLE I
RANKING OF TIME RELATED FACTORS

| S.No | Factors Affecting the Time of Construction Project | Mean | Rank |
|---|---|---|---|
| 1 | Project size and location | 3.16 | 11 |
| 2 | Availability of equipments and materials | 2.84 | 14 |
| 3 | Poor planning and scheduling of the project | 3.60 | 4 |
| 4 | Presence of unskilled labours | 3.44 | 7 |
| 5 | Risk and uncertainty associated with project | 3.76 | 3 |
| 6 | Slow decision making from owner | 3.86 | 2 |
| 7 | Delay in progress payments by the owner | 3.96 | 1 |
| 8 | Owner/ engineer interference in the project | 3.28 | 9 |
| 9 | Too many change orders from owner | 3.48 | 6 |
| 10 | High level of quality requirements | 2.64 | 16 |
| 11 | Severe weather conditions on the job site | 3.76 | 3 |
| 12 | No. of construction activity going at the same time | 2.76 | 15 |
| 13 | Soil condition in the construction site | 3.16 | 11 |
| 14 | Claims and disputes in the job site | 2.84 | 14 |
| 15 | Labour strike will cause delay in construction | 3.16 | 11 |
| 16 | Equipment conditions greatly affects the productivity | 3.12 | 12 |
| 17 | Frequent equipment breakdowns | 3.36 | 8 |
| 18 | Modification in material specifications | 2.88 | 13 |
| 19 | Delay in materials delivery | 3.52 | 5 |
| 20 | Dependency on imported materials | 3.20 | 10 |

From the analysis, Delay in progress payments by the owner and is ranked 1st with the mean value of 3.96, since it score highest response from the survey conducted in time related factors. Slow decision making from owner is ranked 2nd with the mean value of 3.86. Risk and uncertainty associated with project and Severe weather conditions on the job site is ranked 3rd with the mean value of 3.76. Poor planning and scheduling of the project is ranked 4th with the mean value of 3.60.

TABLE II
RANKING OF COST RELATED FACTORS

| S.No | Factors Affecting The Cost Of Construction Project | Mean | Rank |
|---|---|---|---|
| 1 | Instability of market conditions | 3.60 | 4 |
| 2 | Risk in fluctuation of material prices | 3.32 | 9 |
| 3 | Variation in taxation for various resources | 3.08 | 12 |
| 4 | Number of bidders on competitive projects | 3.44 | 7 |
| 5 | Risk in fluctuation of labour prices | 3.40 | 8 |
| 6 | Frequent change in design | 3.96 | 1 |
| 7 | Change in specifications during construction | 3.56 | 6 |
| 8 | Construction method and technology | 3.4 | 8 |
| 9 | Estimation error | 2.80 | 15 |
| 10 | Off/on-site operations sequence and limitations | 2.84 | 14 |
| 11 | Resource wastage on site during construction | 3.88 | 2 |
| 12 | Delay in material procurement | 3.16 | 10 |
| 13 | Labour productivity | 3.56 | 6 |
| 14 | Shortage of skilled labours and unskilled labours | 3.04 | 13 |
| 15 | Demand of equipments and materials | 3.58 | 5 |
| 16 | Inappropriate construction methods | 2.80 | 15 |
| 17 | Client requirements on quality | 3.56 | 6 |
| 18 | Incorrect planning and scheduling by contractors | 3.12 | 11 |
| 19 | Additional work in the site | 3.32 | 9 |
| 20 | Mistakes and rework during construction | 3.84 | 3 |

From the analysis, frequent change in design is ranked 1$^{st}$ with the mean value of 3.96. Resource wastage on site during construction is ranked 2$^{nd}$ with the mean value of 3.88. Mistakes and rework during construction is ranked 3$^{rd}$ with mean value of 3.84. Instability of market condition is ranked 4$^{th}$ with the mean value of 3.60. Demand of equipment's and materials is ranked 5$^{th}$ with mean value of 3.58.

TABLE III
RANKING OF COST RELATED FACTORS

| S.No | Factors Affecting the Quality of Construction Project | Mean | Rank |
|---|---|---|---|
| 1 | Lack of management commitment to quality | 3.00 | 14 |
| 2 | Lack of management leadership and involvement | 3.24 | 10 |
| 3 | Poor financial control on site | 3.12 | 13 |
| 4 | Lack of labour productivity | 3.12 | 13 |
| 5 | Contractor poor site management & supervision | 3.76 | 2 |
| 6 | Poor information and communication channels | 3.12 | 13 |
| 7 | Lack of coordination b/w designer & contractor | 3.68 | 4 |
| 8 | Too many change orders in the work | 3.84 | 1 |
| 9 | Poor quality of design and specifications | 3.28 | 9 |
| 10 | Inefficient team work among stakeholders | 3.32 | 8 |
| 11 | Poor quality of equipments and raw materials | 3.72 | 3 |
| 12 | Lack of advanced technology in construction | 3.16 | 12 |
| 13 | Poor utilization of equipments and materials | 3.52 | 5 |
| 14 | Construction method and technology | 2.92 | 16 |
| 15 | Late delivery of materials and equipments | 2.96 | 15 |
| 16 | Poor planning and scheduling techniques | 2.92 | 16 |
| 17 | Lack of technical and professional expertise to perform task | 3.68 | 4 |
| 18 | Mistakes during construction and rework | 3.42 | 7 |
| 19 | Construction quality control meetings and training | 3.2 | 11 |
| 20 | Lack of monitoring by the project team members | 3.48 | 6 |

From the analysis, too many change orders in the work is ranked 1st with the mean value of 3.84. Contractor's poor site management and supervision is ranked 2nd with the mean value of 3.76. Poor quality of equipment's and raw materials is ranked 3rd with the mean value of 3.72. Lack of coordination b/w designers & contractors and Lack of technical and professional expertise to perform task are ranked 4th with the mean value of 3.68.

## VIII. CONCLUSIONS

A questionnaire-based survey was conducted from owners, site engineers and contractors from various companies through direct survey. From survey 92 responses were collected and analyzed by using SPSS software. Based on the results the factors are ranked by degree of importance.Slow decision making from owner, delay in progress payments by the owner, risk and uncertainty associated with project, Poor planning and scheduling of the project, severe weather conditions on the job site are the major factors which affecting the time of construction project.

Frequent change in design, resource wastage on site during construction, mistakes and rework during construction, Instability of market conditions, demand of equipments and materials are the major factors which affecting the cost of construction project. Too many change orders in the work, contractor's poor site management and supervision, poor quality of equipments and raw materials, lack of coordination between designers and contractors, lack of technical and professional expertise to perform task are the major factors which affecting the quality of construction project.

In continuation of my project, more responses have to be obtained in future and the survey results are to be analyzed. More data can be obtained which will help to know more about the factors affecting time, cost and quality. It will facilitate the improvements in optimization of time, cost and quality in construction projects.

The following recommendations are deducted from this study to complete the project on time, within budget and achieving best quality,

*A.* The payment by owner should be made in time for completion of project in time.
*B.* Early identification of risk at the beginning of a project is considered essential for project time control to be effective.
*C.* Weather is the most uncontrollable factor among the other variables considered. Temperature and humidity affect productivity of workers.
*D.* Perform a pre-construction planning of project task and resources needs. Proper scheduling is the key to utilizing project resources, if it not, the project cost will increase.
*E.* Frequent change in design leads to additional cost and time consumption. This problem arose from inadequate project plann,ing and management of the design process.
*F.* Wastage on site has to be considered on tendering any project. To overcome the wastages proper material planning is required.
*G.* Rework of mistakes during construction will leads to increase in total project cost. Mistakes are done due to incorrect planning and poor site management.
*H.* Skilled labour is required to achieve a high quality of work.
*I.* Proper planning and effective supervision is required to achieve a high quality of work.
*J.* Good quality of equipments and raw materials should be used to achieve a high quality of work in construction project.

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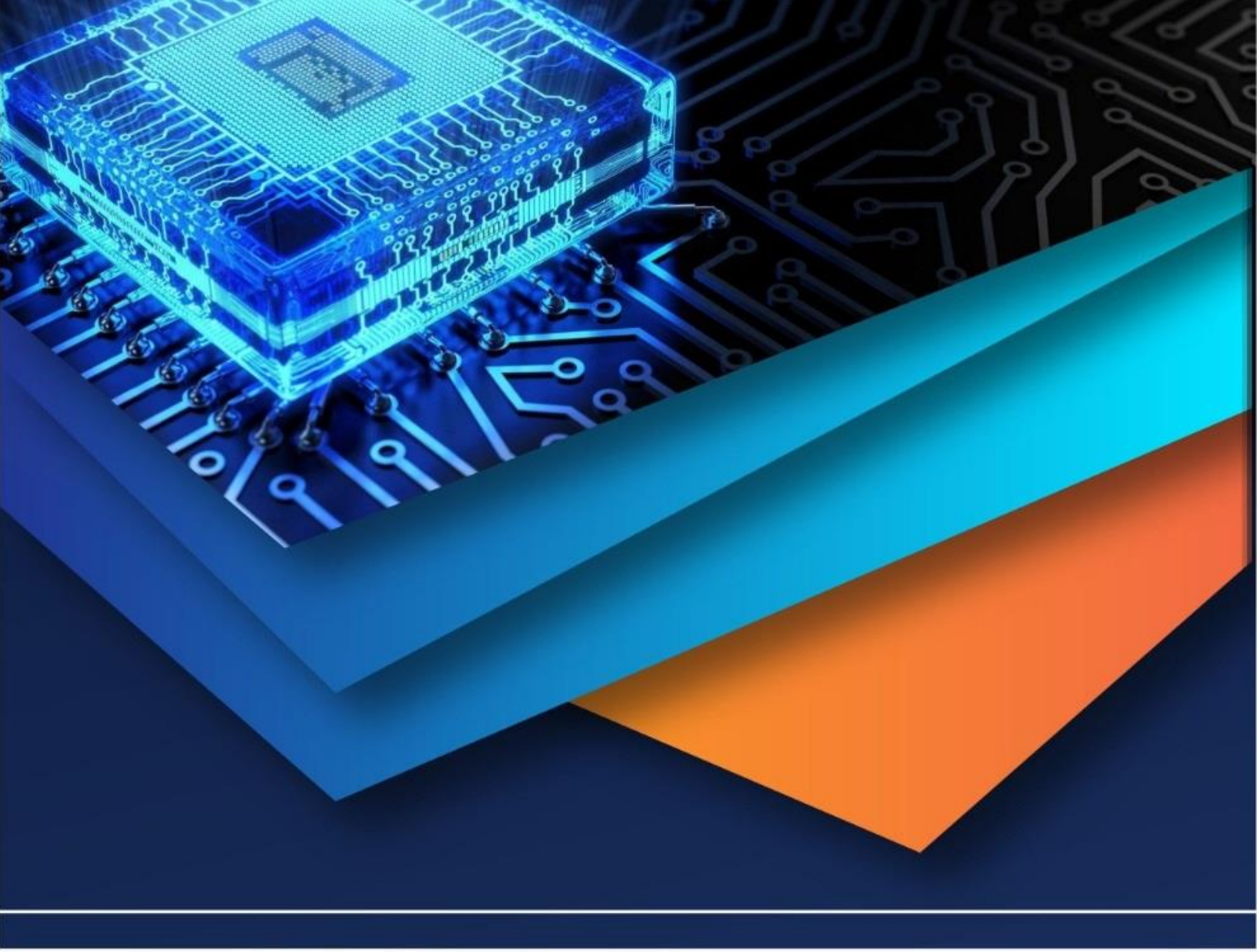

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