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**AN IMPROVED CONSTRUCTION TECHNOLOGY AND MANAGEMENT (CTM) SYSTEM****RAKESH GUPTA****STUDENT****DEPARTMENT OF CIVIL ENGINEERING  
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GWALIOR****ABSTRACT**

*Construction management or construction project management (CPM) is the overall planning, coordination, and control of a project from beginning to completion. CPM is aimed at meeting a client's requirement in order to produce a functionally and financially viable project. Cost is one of the primary measures of a project's success. This is true, especially for public projects in developing countries like India, because public construction projects in these countries are executed with scarce financial resources. In this paper we proposed an improved budget oriented scheme in Construction Technology and Management (CTM) system. Our proposed scheme solved the cost overgrow problem and improved the overall effect of the construction industry projects.*

**KEYWORDS**

CTM, Cost Overgrow, Construction Industry, CPM.

**INTRODUCTION**

A construction manager should have the ability to handle public safety, time management, cost management, quality management, decision making, mathematics, working drawings, and human resources. The Construction Management Association of America says the 120 most common responsibilities of a Construction Manager fall into the following 7 categories: Project Management Planning, Cost Management, Time Management, Quality Management, Contract Administration, Safety Management, and CM Professional Practice. CM professional practice includes specific activities, such as defining the responsibilities and management structure of the project management team, organizing and leading by implementing project controls, defining roles and responsibilities, developing communication protocols, and identifying elements of project design and construction likely to give rise to disputes and claims [1-2]. Cost is one of the primary measures of a project's success. This is true, especially for public projects in developing countries like India, because public construction projects in these countries are executed with scarce financial resources. Most literature review on construction projects suggested that the common criteria for project success are generally considered to be cost, time and quality. In India, the present state of the construction industry falls short of meeting domestic and international quality standards and the performance demand expected from the sector. Construction projects have problems with construction techniques and management as well as limitation of funds and time. The critical problems are inability to complete the projects on schedule; low quality work and cost overgrow. In general, most construction projects experience time overgrow and cost overgrows during their execution phase [3-4]. This paper proposed an improved CTM system for identifying the main causes of cost overgrow and their overall effects for public building construction projects and the related responsible party to the causes of cost overgrows.

**BACKGROUND ON CTM****CONSTRUCTION AS AN INDUSTRY**

The construction industry is composed of five sectors: residential, commercial, and heavy civil, industrial, and environmental. A construction manager holds the same responsibilities and completes the same processes in each sector. All that separates a construction manager in one sector from one in another is the knowledge of the construction site. This may include different types of equipment, materials, subcontractors, and possibly locations. In 2010 the Chartered Institute of Building published its construction management definition based upon the Institute's 45,000 members and the work they do. The designation Chartered Construction Manager is available to full corporate members (MCIOB) and fellows (FCIOB) of the Chartered Institute of Building [1] and [5].

**THE ROLE OF A CONTRACTOR**

A contractor is assigned to a construction project once the design has been completed by the person or is still in progress. This is done by going through a bidding process with different contractors. The contractor is selected by using one of three common selection methods: low-bid selection, best-value selection, or qualifications-based selection. This is the main role of a contractor.

**BIDS**

A bid is given to the owner by construction managers that are willing to complete their construction project. A bid tells the owner how much money they should expect to pay the construction management company in order for them to complete the project.

**Open Bid:** An open bid is used for public projects. Any and all contractors are allowed to submit their bid due to public advertising.

**Closed Bid:** A closed bid is used for private projects. A selection of contractors is sent an invitation for bid so only they can submit a bid for the specified project [4-6].

#### SELECTION METHODS

**Low-bid selection:** This selection focuses on the price of a project. Multiple construction management companies submit a bid to the owner that is the lowest amount they are willing to do the job for. Then the owner usually chooses the company with the lowest bid to complete the job for them.

**Best-value selection:** This selection focuses on both the price and qualifications of the contractors submitting bids. This means that the owner chooses the contractor with the best price and the best qualifications. The owner decides by using a request for proposal (RFP), which provides the owner with the contractor's exact form of scheduling and budgeting that the contractor expects to use for the project.

**Qualifications-based selection:** This selection is used when the owner decides to choose the contractor only on the basis of their qualifications. The owner then uses a request for qualifications (RFQ), which provides the owner with the contractor's experience, management plans, project organization, and budget and schedule performance. The owner may also ask for safety records and individual credentials of their members.

#### PAYMENT CONTRACTS

**Lump-sum:** This is the most common type of contract. The construction manager and the owner agree on the overall cost of the construction project and the owner is responsible for paying that amount whether the construction project exceeds or falls below the agreed price of payment.

**Cost-Plus-Fee:** This contract provides payment for the contractor including the total cost of the project as well as a fixed fee or percentage of the total cost. This contract is beneficial to the contractor since any additional costs will be paid for even though they were unexpected for the owner.

**Guaranteed Maximum Price:** This contract is the same as the cost-plus-fee contract although there is a set price that the overall cost and fee do not go above.

**Unit-Price:** This contract is used when the cost cannot be determined ahead of time. The owner provides materials with a specific unit price to limit spending.

#### PERFORMANCE MEASUREMENT SYSTEM DESIGN

An organization cannot have an effective performance management system if the metrics used do not relate to its strategic objectives; for any results coming out of a performance management system used to evaluate the extent to which these objectives have been met, the system will need to have strategy as its main input. An in-depth consideration of the organization's strategic goals is essential, as is an understanding of the revenue logic and processes involved in developing a measurement system and its metrics.

The Performance Pyramid and the Goal Question Metric are examples of linking strategy and operations by translating strategic objectives from top down to practical metrics. Likewise, the Balanced Scorecard (BSC) is a framework that takes into account the chain of cause-and-effect relationships among objectives, activities and results. The other recognized framework, The EFQM Excellence Model, is designed to allow companies to assess whether they are on "the path of excellence." The model enables a comprehensive, systematic and regular review of an organization's activities and results referenced against criteria that are internal to the model [7-8].

#### PROPOSED CONSTRUCTION PROJECT MANAGEMENT

The research is a practical problem developed from the observation of construction projects and the research questions are oriented to investigate the cause of cost overgrow and their effects. This research can be categorized as applied, exploratory, descriptive and co-relational type. It is applied and exploratory because the research was initiated from practical problems and finds whether there exists cost overgrow or not. It is also descriptive and co-relational because it tried to describe the actual rate of cost overgrow and the variables of cost overgrow and tries to draw relationship between contract amount and rate of cost overgrow in the public building construction projects.

Cost overgrows in building construction projects are caused by many factors. Each causes of cost overgrow have different rates of occurrences and their impact on the final cost of the construction project also varies. Therefore, it is important to identify both key causes of cost overgrow based on their occurrence and their impact on building construction projects. The effects of cost overgrow on the stakeholders, on the construction industry, and on the national economy of the country are identified.

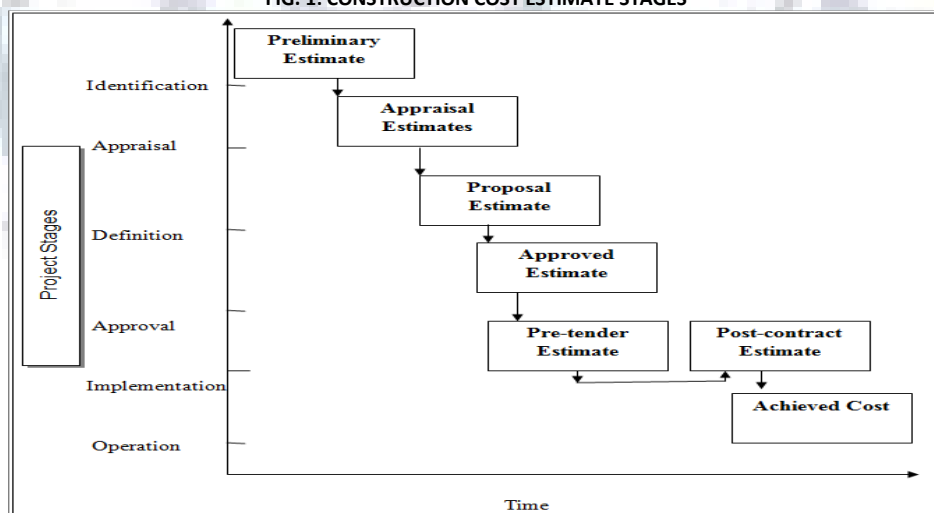
#### PROPOSED COST ESTIMATING METHOD'S STAGES

This paper is proposed and then developed, through time the estimate preparation and information will change based on the needs of the owner or the designer. Generally,, cost estimating is a dynamic process that begins in the early stages of a project and ends when the project is completed and turned over to the owner. It is important to consider the project stages at which estimates can realistically and usefully be produced so that there is a sound basis for deciding whether or not to proceed to the next stage. The number of stages in a project is influenced by the project delivery strategy adopted. The traditional civil engineering projects can be divided into six stages:

1. Identification,
2. Appraisal,
3. Definition,
4. Approval,
5. Implementation
6. Operation.

These stages may not be appropriate for every project and cannot be adhered to exclusively,, but they do offer a rational and structured approach which is applicable to many construction projects. Figure 1 shows the sequence of these project stages and indicates the types of estimate used in each stage.

FIG. 1: CONSTRUCTION COST ESTIMATE STAGES





**PRELIMINARY ESTIMATE**

This is an initial estimate at the earliest possible stages. It is likely that no design data will be available and that there will be only a crude indication of the project size or capacity. The preliminary estimate is likely to be of use in the provisional planning of capital expenditure program.

**APPRAISAL ESTIMATES**

Sometimes known as feasibility estimates;; these are directly comparable estimates of the alternative schemes under consideration.

**PROPOSAL ESTIMATE**

This is an estimate for the selected scheme. A proposal estimate is usually based on a conceptual design and design study specifications.

**APPROVED ESTIMATE**

A modified version of the proposal estimate to reflect the client's views, which is intended to provide the basis for project cost control.

**PRE-TENDER ESTIMATE**

A refinement of the approved estimate based on the definitive design work using the information provided in the tender documents which should be used during bid evaluation as a marker against which bids can be assessed.

**POST-CONTRACT ESTIMATE**

Once the design documents are complete,, companies interested in actually performing the work price the project. At this level the cost estimate is made by contractors who want to execute the project. This estimate is the most important. It carries with it legal implications; if the bid is accepted, a construction company is legally bound to a specific price for a specific scope of work.

This estimate serves as a base-line cost for comparing the deviation of the actual cost from the initial contractors estimate. It also serves for controlling and managing costs during construction phase.

**ACTUAL COST**

This is a record of the actual costs of the job in order to review performance and provide data for future projects. It is useful to compare the actual use and expenditure of allowances and contingencies with those included in the various estimates.

Every estimate, whether prepared in the early phase of the project or at tender time considers the same basic issues. Project price is affected by the size of the project, the quality of the project, the location, construction start time and duration, and other general market conditions, etc. The accuracy of an estimate is directly affected the availabilities of data and by the ability of the estimator to properly analyze these basic data.

**PROPOSED METHOD ANALYSIS**

Both descriptive and inferential statistics are employed in the data analysis. In the analysis the "Mean Score" method is adopted to establish the relative importance of the causes of cost overgrow for public building construction projects in India. As discussed earlier Likert's scale of five ordinal measures of agreement towards each statement is used to calculate the mean score for each factor that is used to determine the relative ranking. The mean score (MS) for each variables of cost overgrow is computed by using the following formula;

$$MS = \frac{\sum(f \times S)}{N}$$

Where:

**MS** - Mean Score

**f** – Frequency of responses for each score

**S** – Scores given to each factor (from 0 to 4)

**N** – Total number of responses concerning each factor

The Spearman (rho) rank correlation coefficient is used for measuring the differences in ranking between two groups of respondents scoring for various factors (i.e. clients versus consultants, clients versus contractors, and consultants versus contractors). The Spearman (rho) rank correlation coefficient for any two groups of ranking is given by the following formula:

**Spearman rank correlation coefficient=**  $1 - \frac{6 \times \sum (\text{The difference in ranking between each pair of factors})^2}{N \times (N^2 - 1)}$

**Procedure for hypothesis testing:**

1. Define the null hypothesis (H0) and the alternative hypothesis (HA)
2. Choose a value for the significance level
3. Calculate the value of the test statistic, Spearman rank correlation coefficient.
4. Compare the calculated value with a table of the critical values of the test statistic.
5. If the calculated value of the test statistic is less than the critical value from the table, accept the null hypothesis (H0). If the absolute (calculated) value of the test statistic is greater than or equal to the critical value from the table, reject the null hypothesis (H0) and accept the alternative hypothesis (HA).

**RESULTS DISCUSSION****QUESTIONNAIRE SURVEY**

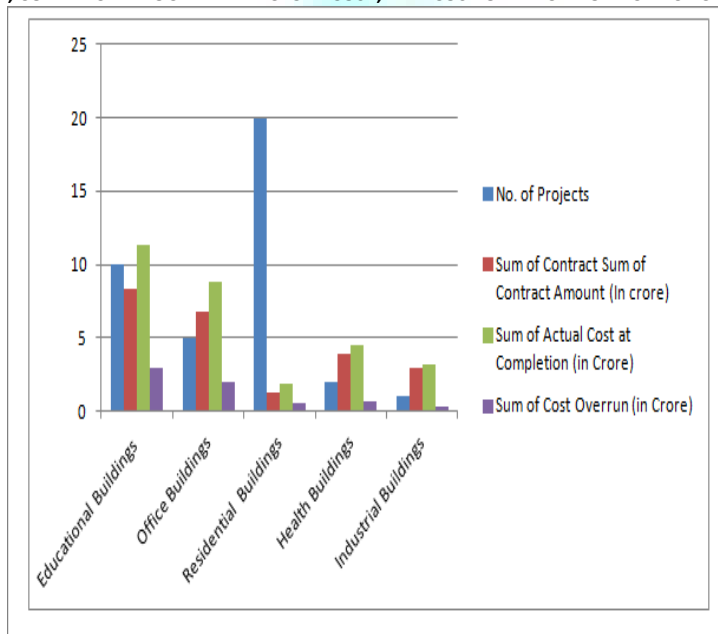
This part of the research deals with the analysis and discussion of the data gathered from the desk study and questionnaire survey. It includes the identification of the existence and extent of cost overgrow, relationship between rate of cost overgrow and contract amount, main causes of cost overgrow, rate of occurrences of variables of cost overgrow, the impact of the variables of cost overgrow on the final/total cost of the project. Finally, the effects of cost overgrow on the various stakeholders, on the construction industry, and on the national economy in general will be dealt. The procedure used in analyzing the results was aimed at establishing the relative importances of the various factors responsible for cost overgrow and their effects. The questionnaire gave each respondent an opportunity to identify the factor that was likely to cause cost overgrow by giving the response "I strongly disagree", "I disagree", "I agree", etc; frequency occurrence of the variables of cost overgrow ; and the impacts of each cost. Overgrow variables on the final cost of the project. For each variables of cost overgrow, the percentages of respondents' response were ranked for analysis purpose. On the basis of the ranking of the variables by the various groups, it was possible to identify the most important factors that influenced cost overgrows in public building construction projects. From the desk study a variety of completed public building construction projects throughout in India were surveyed. During the desk study all the documents of each project such as correspondence letters, project report, payment certificate, the contract amount, contract time during signing of the contract actual cost and actual completion time at completion of the project were thoroughly investigated. These help to understand the reasons behind each project for cost overgrow, and to investigate how the actual cost at completion deviates from the contract amount. Collecting these data helped to analyze and draw the relationship between rates of cost overgrow and contract amount.

The table 1 and figure 2 represents value and graph of project type of contract amount and actual cost, and Cost overrun for public building construction projects.

TABLE 1: VALUE OF PROJECT TYPE, CONTRACT AMOUNT AND ACTUAL COST, AND COST OVERRUN FOR PUBLIC BUILDING CONSTRUCTION PROJECTS

	No. of Projects	Sum of Contract Sum of Contract Amount (In crore)	Sum of Actual Cost at Completion (in Crore)	Sum of Cost Overrun (in Crore)
Educational Buildings	10	8.34	11.33	2.99
Office Buildings	5	6.77	8.76	1.99
Residential Buildings	20	1.32	1.84	0.52
Health Buildings	2	3.87	4.54	0.67
Industrial Buildings	1	2.98	3.23	0.25

FIGURE 2: THE OF PROJECT TYPE, CONTRACT AMOUNT AND ACTUAL COST, AND COST OVERRUN FOR PUBLIC BUILDING CONSTRUCTION PROJECTS



#### QUESTIONNAIRE RESPONSE RATE

Detailed questionnaires were designed and distributed for the assessment of cost overrun on public building construction projects, for this purpose the questionnaires were distributed to major stakeholders in the construction industry; these are Contractors, Consultants and Clients (project owners). To make the analysis more comprehensive a total of 62 questionnaires were distributed to consultants, contractors and clients (project owners) out of whom 38 questionnaires were filled and returned.

#### RELATIONSHIP BETWEEN RATE OF COST OVERRUN AND CONTRACT AMOUNT

In the literature review part of this research paper it was indicated that the size of the project determines the rate of cost overrun, however, it is important to determine how rate of cost overrun varies with project size. As indicated in the literature review part of this paper, there were two ideas which contradict each other; found that cost overrun rates decreased with increase in the contract amount of construction projects, while Rowland, found that cost overrun rates increased with increase in the contract amount of construction projects. This section of the paper will identify the relationship between rate of cost overrun and contract amount; how the rate of cost overrun varies with contract amount.

#### CAUSES OF COST OVERRUN FROM DESK STUDY AND QUESTIONNAIRE RESPONSE

It has been found from the desk study that the most common causes of cost overrun are supplementary agreement, price fluctuation of construction materials particularly cement, reinforcement bar, fuel, and asphalt; change orders or variations due to enhancement initiated by clients, excess quantity during construction, unexpected or unforeseeable ground condition, mistakes during planning, design and contract documents preparation, etc.

#### HYPOTHESIZED CAUSES OF COST OVERRUN

1. Inflation or increase in the cost of construction materials
2. Lack of planning and coordination or less emphasis to planning
3. Fluctuations in the cost of labor and/or material or any other matter affecting the cost of the execution of the works and subsequent legislation that affect the project
4. Insufficient geotechnical investigation
5. Additional costs due to variations works
6. Change in foreign exchange rate (for imported materials)
7. Change orders and/or lack of control on excessive change orders
8. Costs due to special risks which very often include outbreak of war, projectile missile, hostilities, contamination and other such risks
9. Delay of drawings and/or order requested by the contractor in accordance with Sub Clause
10. Changes in Plans and drawings
11. Inappropriate/inexperienced contractor
12. Encountering of not foreseeable physical obstructions and conditions
13. Failure to identify problems and institute necessary and timely design and programming changes
14. Failure on the part of the employer to give possession of the site in accordance with the terms of the contract
15. Inaccurate quantity estimate or excess quantity during construction
16. Unclear specifications or changes to specification

17. Contractors bankruptcy
18. Cost under estimation
19. Additions and/or enhancement required by clients or end users
20. Difficulties in obtaining construction materials in the local market Government & Contractor
21. Errors in setting out which are based on incorrect written data supplied by the Engineer consultant
22. Ambiguities or discrepancies of documents Consultant
23. Loss or damage due to excepted risks or employers risk Government, Client & others
24. Suspension of work ordered by the Engineer Consultant
25. Complexity of construction projects Consultant & Contractor
26. Poor communication among contractor, consultant, and the client, Consultant & Contractor
27. Mistakes during construction or defective work Consultant & Contractor
28. Supplementary/additional agreement Client & consultant
29. Cost associated with test of samples not provided in the contract Client & Consultant
30. Funding problems or client's shortage of finance or delayed payments to contractors Client
31. Lack of end user involvement Client, Consultant & end user
32. Executive bureaucracy in the client's organization Client
33. Un-covering of works that has already been completed, but they are found to be executed in accordance with the contract Client & Consultant
34. Acceleration required by the owner Client & end user
35. Indemnities that the employer has contractually undertaken to assume Client & others
36. Different consultant for Design, Supervision & Contract Administration Consultant
37. Increase in tax/change in government fiscal/monetary policies Government
38. Searching for defects which are not the fault of the contractor

**The major causes of cost overgrow are inflation or** increase in the cost of construction materials, poor planning and coordination or less emphasis to planning, fluctuation in the cost of materials according.

### IDENTIFYING CAUSES OF COST OVERGROW BASED ON RATE OF OCCURRENCE

The most frequent causes of cost overgrow were assessed from respondents and results are given. The causes of cost overgrow which have a mean score of greater than or equal to 2 (MS  $\geq 2$ ) rate of occurrence are considered as important because there is at least a probability of 50% chance for the occurrence.

#### HYPOTHESIZED CAUSES OF COST OVERGROW

1. Inflation or increase in the cost of construction materials
2. Fluctuations in the cost of labor and/or material or any other mater affecting the cost of the execution of the works and subsequent legislation that affect the project
3. Change in foreign exchange rate (for imported materials)
4. Change orders and/or Lack of control on excessive change orders
5. Lack of planning and coordination or less emphasis to planning
6. Additional costs due to variations works
7. Failure to identify problems and institute necessary and timely design and programming changes
8. Changes in Plans and drawings
9. Insufficient geotechnical investigation
10. Contractors bankruptcy
11. Difficulties in obtaining construction materials in the local market
12. Cost under estimation
13. Inaccurate quantity estimate or excess quantity during construction
14. Delay of drawings and/or order requested by the contractor in accordance with Sub Clause
15. Inappropriate/Inexperienced contractor
16. Supplementary/additional agreement
17. Ambiguities or discrepancies of documents
18. Poor communication among contractor, consultant, and the client
19. Encountering of not foreseeable physical obstructions and conditions
20. 21 Executive bureaucracy in the client's organization
21. Suspension of work ordered by the Engineer
22. Failure on the part of the employer to give possession of the site in accordance with the terms of the contract
23. Failure on the part of the employer to give possession of the site in accordance with the terms of the contract

As indicated on above, inflation or increase in the cost of construction materials, change in foreign exchange rate, and lack of planning and coordination or less emphasis to planning, change orders or variation orders are the top most frequently encountered causes of cost overgrow. Whereas force majeure related causes of cost overgrow such as outbreak of war, hostilities, uprisings, etc., are rarely encountered in the Ethiopian construction industry. Since the occurrences of causes of cost overgrow related to force majeure are rare, they have low rank.

### IDENTIFYING OF CAUSES OF COST OVERGROW BASED ON IMPACT

As discussed previously identifying the rate of occurrence only will not help in identifying factors that are critical in causing cost overgrow; regardless of the chance of occurrence the significance of the factor independently has to be gauged with respect to its severity, when it happens during construction phase.

#### HYPOTHESIZED CAUSES OF COST OVERGROW

1. Inflation or increase in the cost of construction materials
2. Fluctuations in the cost of labor and/or material or any other mater affecting the cost of the execution of the works and subsequent legislation that affect the project
3. Costs due to special risks which very often include outbreak of war, projectile missile, hostilities, contamination and other such risks
4. Change in foreign exchange rate (for imported materials)
5. Additional costs due to variations works
6. Changes orders or lack of control on excessive change orders
7. Insufficient geotechnical investigation
8. Difficulties in obtaining construction materials in the local market
9. Ambiguities or discrepancies of documents
10. Encountering of not foreseeable physical obstructions and conditions
11. Contractors bankruptcy
12. Inappropriate/Inexperienced contractor

13. Lack of planning and coordination or less emphasis to planning
14. Failure to identify problems and institute necessary and timely design and programming changes
15. Changes in Plans and drawings
16. Failure on the part of the employer to give possession of the site in accordance with the terms of the contract
17. Inaccurate quantity estimate or excess quantity during construction
18. Cost under estimation
19. Unclear specifications or changes in specification
20. Poor communication among contractor, consultant, and the client

The above finance related causes of cost overgrow such as inflation or increase in the cost of construction materials, fluctuation in the cost of materials according to conditions of contract, etc and force majeure related such as outbreak of war, up risings, etc have higher impact on the final cost of the project at completion. Even if force majeure related causes of cost overgrow have severe impact on the final cost of the project at completion their rate of occurrence is low.

## EFFECTS OF COST OVERGROW

Although the degree of effects of cost overgrow varies on the stakeholders in the construction industry, all the parties involved are affected by cost overgrow. Generally, the following are the main effects of cost overgrow which are collected from the respondents of the questionnaire survey and desk study.

1. Delay,
2. Supplementary agreement,
3. Additional cost, budget short fall,
4. Adversarial relationship between participants of the project,
5. Loss of reputation to the consultant, the consultant will be viewed as incompetent by project owners,
6. High cost of supervision and contract administration for consultants,
7. Delayed payments to contractors,
8. The contractor will suffer from budget short fall of the client,
9. Poor quality workmanship,
10. Dissatisfaction by project owners and consequently by end users,
11. Negative attitude towards the construction industry by the higher public authority and by the society as a whole,
12. The contribution of the construction industry to the growth of national economy of the country will be less,
13. Cost overgrows in construction projects prevent the planned increase in property and service production from taking place, and this phenomenon in turn affects, in a negative way, the rate of national growth,
14. Weekends the growth of the construction industry by eroding mutual trust and respect,
15. Pours money unnecessarily to the project at hand at the expense of other new projects,

One of the common effects of cost overgrow is delay; this in turn affects clients, consultants and contractors. Furthermore, lengthy delays increase cost overgrows tremendously. Excessive cost overgrow requires additional budget, this in turn eat up the scarce financial resources of the country, which lead to further budget short fall for construction projects. This prevents the planned increase in property and service production from taking place, and this phenomenon in turn affects, in a negative way, the rate of national growth. Costs overgrow will also be a source of dispute among stakeholders and it lead to adversarial relationship among project participants. Project owners will lose confidence on consultant and on professionals in general. To the industry as a whole, cost overgrows could bring about a drop in building activities, bad reputation, and inability to secure project finance easily from public authorities in the future. All these effects undermine the viability and sustainability of the construction industry.

## CONCLUSION

Financial resources are so scarce in developing countries like India, hence, cost related issues in the Indian construction industry are sensitive issues. Therefore, carrying out a research in this area will have a paramount importance. Identification of causes of cost overrun is a prerequisite to minimize or to avoid cost overrun in the construction industry. The main objective of this research is, therefore, to identify and investigate the critical causes and effects of cost overrun on public building construction projects in India. Desk study was used to identify the existence and extent of cost overrun on public building construction projects in India. Questionnaire survey was also used to identify the causes and effects of cost overrun. Clients, consultants and contractors were asked to identify the variables of cost overrun in the Indian construction industry. The analysis of the results from the open-ended part of the questionnaire was carried out using descriptive analysis.

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