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Shubham Sharma and Ashok Kumar Gupta

1 Introduction

Cost overrun and delay in projects is a foremost challenge associated with nearly all projects in the construction industry. Inclination of construction projects towards overruns is because of risk and uncertainties involved in these projects. In developing countries, this problem is more severe as in some projects cost and time exceed double the amount than anticipated [1]. Construction plays an important role in economic growth of a country and also considered as largest generator of employment opportunities. Despite of its importance in development of a country, it has to face many challenges. In construction industry, a project is considered as successful if it meets both the criteria of budget and deadline [2]. Construction projects that fail to meet these criteria will have to face losses in terms of cost and time. To complete the project within budget and deadline, generally quality of project delivered is sacrificed. The major reason for these overruns is the lack of knowledge regarding the factors affecting cost and time. A construction project mainly consists of two major phases, namely pre-construction phase and construction phase. There is a need of applying risk management process in both the stages of the project. Both the stages play an important role in successful completion of project objectives. First stage is mainly about planning, scheduling, deciding budget, etc. Pre-construction is considered an important stage if managed precisely ensures more profits and less uncertainties [3]. Second stage consists of implementation of the things that was planned and scheduled in first stage with continuous monitoring and controlling. Overruns can affect the project objectives in terms of cost, time, quality and productivity [4]. In

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this research for identification and management of overrun in construction projects, we will use framework consisting of three steps, namely identification of factors responsible for overruns, assessment of identified factors and providing mitigation measures [5]. The aim of this research is to identify critical overrun factors present in construction industry and to manage them such that it has minimum negative effects on the project cost and time.

2 Background Study

A number of factors are responsible for cost and time overruns in construction projects. Previous studies have defined cost overrun in a project as the difference between total cost required for completion of project and the estimated/budgeting cost at time of agreement or contract [6, 7]. According to the literature, time overrun is defined as difference between time required for completion of the project and time agreed in agreement or contract for delivering the completed project [8]. The results of past studies clearly state that cost and time overrun badly affects the project as well as the associated construction companies. In some case, even companies go bankrupt due to these overruns [9]. So, there is need of systematic study of these overruns which can provides clarity about the critical overrun factors involved. The first step suggested by literature is identification of factors involved in construction projects. This is an important step as without knowing what factors are involved, we cannot proceed further [10]. Next step is assessment of the identified overrun factors. This step will help us in identifying critical factors having maximum impact on overruns. Last step is suggesting mitigation measures and continuous monitoring over the construction process. For positive results, monitoring and control are important as new overrun factor can emerge at any time during the construction process.

3 Research Methodology

3.1 Overrun Factors Identification

Starting with the identification of cost and time overrun factors involved in construction projects. A total of forty-four overrun factors were identified through a detailed literature review related to cost and time overruns. Then, these factors were categorized into four major categories, namely project scope, management related, legal constraints faced and site-resource related. Project scope category consists of eight factors, management category consists of six factors, legal-constraint category and site-resource-related category consist of fifteen factors each.

Table 1 Role and years of experience of respondents

Category	Range	Number of participants
Role of participants	Project manager	19
	Site supervisor	32
	Engineer	41
	Contractor	9
	Consultant	4
Years of experience	<5 years	18
	5–10 years	32
	10–15 years	25
	15–20 years	17
	>20 years	13

3.2 Questionnaire Survey and Respondents

A questionnaire was prepared from the identified overrun factors. It consists of three parts—first part was about respondents' profile and second part was explaining the Likert scale. A five-point Likert scale (1 = very less impact and 5 = very high impact) was used for assessing the impact of overrun factors. A total of 155 survey forms were distributed, out of which 105 completely filled survey forms were collected and used in this research. Data obtained from Likert scale was assessed in Minitab. The survey was conducted in two states of India, namely Punjab and Himachal Pradesh. This survey was filled by respondents involved in dealing with cost and time overruns. The respondents were having different roles like engineer, site supervisor, project manager, contractor and consultant. These survey forms were filled by respondents having experience of working in different parts of India. So, the results of this study can be generalized for all the construction projects. Fifty-five (52.38%) respondents were having experience of more than ten years in construction industry. Number of respondents along with their roles and years of experience are shown in Table 1.

4 Analysis of Data and Results

4.1 Analysis for Reliability of Questionnaire

Internal consistency of overrun factors and questionnaire survey reliability are important aspects to judge whether the survey results are appropriate or not [11, 12]. This was done by using a statistical software named Minitab to check Cronbach alpha. Generally, Cronbach alpha has a value between 0 and 1. Higher the value higher is

the reliability and internal consistency [13]. Overall, Cronbach alpha for questionnaire was found to be 0.852, which ensures high reliability and internal consistency of data collected.

4.2 Ranking of Overrun Factors

For analysis of different overrun factors, relative importance index (RII) technique was used. This method was found appropriate for ranking of critical risk factors as compared to other methods [14–16]. RII was calculated by using Eq. (1)

$$\text{RII} = \sum a_i * n_i / N * A \tag{1}$$

where $a_i =$ assigned weight to ith response, $n_i =$ frequency of ith response, $N =$ total number of respondents, $A =$ highest weight. Value of RII indicates the impact of factor on cost and time overrun in a project. Higher the value of RII more critical the factor. RII for different categories was found using Eq. (1) and considering factors present in that category only. RII for project category was found to be 0.698, RII for management category was found to be 0.727, RII for legal-constraints faced category was found to be 0.672, and RII for site-resource related category was found to be 0.692. Similarly, Cronbach alpha for different categories was found using Minitab and considering factors present in that category only. Cronbach alpha for project category was found to be 0.723, Cronbach alpha for management category was found to be 0.810, Cronbach alpha for legal-constraints faced category was found to be 0.776, and Cronbach alpha for site-resource-related category was found to be 0.753. RII for different overrun categories along with Cronbach alpha is shown in Table 2.

After calculating RII, overrun factors were arranged in ascending order such that factor with highest RII value was ranked first and factor with lowest RII value was ranked last. The value of RII ranged between 0.8171 (high) and 0.5657 (low) for 44 overrun factors. Top five overrun factors identified in construction projects are

Table 2 Overrun categories with Cronbach alpha and RII

Overrun category	Number of questions	RII	Cronbach alpha
Project	8	0.698	0.723
Management	6	0.727	0.810
Legal and constraints faced	15	0.672	0.776
Site and resource related	15	0.692	0.753

delay in obtaining permission from authorities, poor supervision and site management, unrealistic time schedule, unforeseen ground conditions and lack of skilled professionals. RII value for different overrun factors is calculated in Table 3.

5 Discussion and Guidelines

In previous studies, very less research is done collectively on both the overrun factors, i.e. cost and time [17, 18]. This study identifies the most critical overrun factors responsible for project failures in terms of achieving its objectives within budget and time allocated. Top fifteen overrun factors categorization along with their overall ranking and ranking within category are shown in Table 4. In top fifteen overrun factors, it was found that four factors were from each project-related and management category. Two factors were from legal-constraints category, and five factors were from site-resource-related category. Top factors identified in project-related category were unrealistic time schedule, change in scope of work and rework due to error in execution. Top factors identified from management category were poor supervision and site management, poor leadership and management qualities, and slow decision-making from owner. Top factors recognized from legal-constraints category were delay in obtaining permission from authorities and penalties resulting from low qualities. Top factors identified from site-resource-related category were unforeseen ground conditions, lack of skilled professionals and extreme weather conditions.

For successful achievement of project objectives, this study suggests the following guidelines.

- Developing the framework: A framework should be prepared project-specific for both the stages, i.e. preconstruction stage as well as construction stage.
- Identified overrun factors: Identified overrun factors should be managed as soon as possible to decrease its negative effects and increase positive project outcomes.
- Overrun stage: As overrun can occur in any stage from commencement till accomplishment of the project. These overrun factors should be further divided into following stages to have better understanding and control. These stages are feasibility stage, procurement stage, construction stage, operation stage and transfer stage.
- Monitor and control: New overrun factors keep on emerging in a construction project. Overrun management is an iterative process with continuous addition of new emerged factor in management plan. This ensures better control over cost and time overruns.

6 Conclusion

The findings of this research fill the knowledge gap and discloses the critical overrun factors present in construction industry. Critical overrun factors need to be managed

Table 3 Ranking of overrun factors using RII

Overrun ID	Overrun factor	$\sum W$	RII	Rank
OR19	Delay in obtaining permission from authorities	429	0.8171	1
OR10	Poor supervision and site management	418	0.7962	2
OR2	Unrealistic time schedule	416	0.7924	3
OR35	Unforeseen ground conditions	413	0.7867	4
OR31	Lack of skilled professionals	409	0.7790	5
OR3	Change in scope of work	401	0.7638	6
OR12	Poor leadership and management qualities	400	0.7619	7
OR36	Extreme weather conditions	398	0.7581	8
OR7	Rework due to error in execution	397	0.7562	9
OR15	Penalties resulting from low qualities	396	0.7543	10
OR9	Slow decision-making from owner	393	0.7486	11
OR44	Design changes	387	0.7371	12
OR1	Poor preliminary estimates and understanding	383	0.7295	13
OR30	Poor labour productivity	381	0.7257	14
OR11	Improper planning during bidding stage	380	0.7238	15
OR32	Use of improper construction methods	373	0.7105	16
OR16	Conflict between owners and other parties	371	0.7067	17
OR28	Inadequate experience of contractor	369	0.7029	18
OR43	Unrealistic inspection and testing methods	368	0.7010	19
OR4	Disputes in contract documents	367	0.6990	20
OR13	Poor means of contracting	365	0.6952	21
OR17	Changes in government regulations and laws	362	0.6895	22
OR42	Delay in inspection and testing	359	0.6838	23
OR23	Slow response by the consultant's engineers to inquires	357	0.6800	24
OR33	Shortage of manpower	355	0.6762	25
OR21	Working on multiple projects at same time	352	0.6705	26
OR18	Delays in contractors claims settlements	351	0.6686	27
OR40	Change in material prices or price escalation	348	0.6629	28
OR41	Inefficient use of equipment	344	0.6552	29
OR20	Financial constraints of contractors	343	0.6533	30
OR22	Lack of motivation for contractor, e. g. Incentives	342	0.6514	31
OR24	Bribes and corruption	340	0.6476	32
OR37	Inaccurate specification	339	0.6457	33
OR5	Lack of similar work experience	338	0.6438	34
OR14	Poor organizational structure for client or consultant	335	0.6381	35
OR6	Frequent change of sub-contractors	334	0.6362	36

(continued)

Table 3 (continued)

Overrun ID	Overrun factor	$\sum W$	RII	Rank
OR29	Consultant or architect's reluctance for change	332	0.6324	37
OR34	Site accidents due to negligence	330	0.6286	38
OR39	Delay in handing over of site	329	0.6267	39
OR26	Theft of material	324	0.6171	40
OR27	Knowledge on construction regulations	321	0.6114	41
OR38	Site accidents due to lack of safety measures	317	0.6038	42
OR25	Hostile political conditions	309	0.5886	43
OR8	Improper knowledge of materials required	297	0.5657	44

Table 4 Categorization of top 15 critical overrun factors

Critical overrun factors categorization	RII	Overall ranking	Ranking within category
Project			
Unrealistic time schedule	0.7924	3	1
Change in scope of work	0.7638	6	2
Rework due to error in execution	0.7562	9	3
Poor preliminary estimates and understanding	0.7295	13	4
Management			
Poor supervision and site management	0.7962	2	1
Poor leadership and management qualities	0.7619	7	2
Slow decision-making from owner	0.7486	11	3
Improper planning during bidding stage	0.7238	15	4
Legal and constraints faced			
Delay in obtaining permission from authorities	0.8171	1	1
Penalties resulting from low qualities	0.7543	10	2
Site and resource			
Unforeseen ground conditions	0.7867	4	1
Lack of skilled professionals	0.7790	5	2
Extreme weather conditions	0.7581	8	3
Design changes	0.7371	12	4
Poor labour productivity	0.7257	14	5

before it can negatively affect construction project. Poor management and execution of tasks in project will require extra resources to get back on track. So, overrun factors should be managed as soon as they emerge. Site-resource-related category was found to be most critical with five overrun factors in top fifteen. The top five factors recognized with highest value of RII were delay in obtaining permission from authorities with RII value of 0.8171, poor supervision and site management with RII value of 0.7962, unrealistic time schedule with RII value of 0.7924, unforeseen ground conditions with RII value of 0.7867 and lack of skilled professionals with RII value of 0.7790.

For different construction projects, overrun factors may slightly vary. Further scope of this study is similar identification and ranking of critical overrun factors can be done project specific, i.e. considering a particular project like building project, infrastructure project, energy project, etc. Region of project can also be considered as sometimes factors change according to the location of the project. So, this research is significant for engineers, project managers, construction practitioners, risk managers, etc. as they have to deal with cost and time overrun in construction projects.

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