

# Causes, Impacts and Mitigations of Rework in Construction

S. Deore Akshay<sup>1\*</sup>, B. A. Konnur<sup>2</sup>

<sup>1</sup>P.G. Student, Department of Civil Engineering, Government College of Engineering, Karad, India

<sup>2</sup>Associate Professor, Department of Civil Engineering, Government College of Engineering, Karad, India

\*Corresponding author: fdeore13@gmail.com

**Abstract:** The construction industry has its importance due to economic growth and civilization. Construction projects are complex in nature because they are consisting of various stages and tasks. Due to complexity errors, omissions, defects are commonly happens in construction which results in rework. Rework is major issue in construction. Rework is work procedure that has to be completed more than one in occasion. It is affecting on cost, time, and performance of construction project. It leads to declination of quality and productivity, cost- schedule overrun. Rework analysis for construction projects are done through a questionnaire survey. The aim of this paper is to make analysis for the causes, impacts of rework in construction. From that analysis, determination of mitigation strategies for rework in construction is elaborated in paper.

**Keywords:** Causes, Construction, Impact, Performance, Quality.

## 1. Definition of Rework

Construction project consists of various complexities such as dealing with multiple stakeholders and resultant changes. It is main cause for schedule delays, cost overrun, and parties' dissatisfaction. It creates a difference in between work planned under contract documentation and work actually performed.

The rework most completely defined by Ashford (1992), as it is procedure which makes an item to adjust with original requirements by correction or completion. Rework declines productivity and enhance cost and duration. According to Construction Industry Development Agency, CIDA, rework is 'doing something at least one extra time due to non-conformance to requirements'. The second definition describes rework as the 'procedure that making an item to adjust with the requisites by correction or completion'.

Construction Industry Institute CII (2001) defined field rework as, 'activities that should be done many time and activities which result in undoing the work that is already performed'. The modified definition of rework as 'Activities in the field that have to be done more than once in the field, or activities which remove work previously installed as part of the project regardless of source, where no change order has been issued and no change of scope has been identified by the owner.'

## 2. Literature Review

Aditya Satish Isasare and Abhijit N Bhirud [1] determined that rework hampers the performance of construction leads to quality degradation, delay and increase in budget. Mechanism should be followed for checking the rework after every activity. Structured system and quality supervision helps in rework reduction. Creating awareness and use of systematic rework management helps in reducing overall rework. Aman Sen, A.K. Dwivedi, Dr. M.K. Trivedi [2] have identified that the rework factors identified and calculated rework cost in construction which defined factors causing rework. Analytical hierarchy process tool used for designate the alternatives. Rework cost analysis shown that total rework cost is 18.40% of the total project cost. It concluded that the client and contractor related factors are most responsible for rework in construction projects.

Bon-Gang Hwang [3] investigated the client-related rework in Singapore-based building projects. Research made through survey of 381 projects performed by 51 companies. It confirmed that the client contributed most to rework in the building projects in Singapore. Analysis results reported that the companies that were surveyed obtained client related rework index above 50%, and overall mean CRR was 58.4%, implying that client related rework was still a common problem in Singapore's building projects. CRR increased project cost by 7.1% and caused 3.3 weeks' delay on the average. It had shown that additions and alterations were more likely to experience CRR in construction projects. It was found that 'change of plans or scope by the client', 'inadequate/incomprehensive project objectives by the client' and 'financial problems faced by the client' contributed most to CRR. Bon-Gang Hwang and Stephen R. Thomas [4] have determined the method for identification of sources of rework. Further they determined process for the development of rework mitigation initiatives. Quantification of rework impact on cost performance done by Construction Industry Institute Benchmarking. Which concluded that rework increases cost. Relationship between rework and cost is explained along with mitigation of rework.

P. E. D. Love [10] justified that AU\$375 million program alliance experienced cost-schedule overrun and increase in safety incidents due to rework. Which shown that authentic leadership, empowering and engaging with contractors, and

continuous improvement can reduce the rework. Program alliances can provide cooperative learning and error management culture. David J. Edwards [13] determined the significant variables that contributed to rework through questionnaire survey of 115 civil infrastructure projects. It revealed that mean total rework costs were 10% of the contract value for the sample. The total estimated cost of rework for the projects sampled was found to be 10.29% of the contract value. There was no significant difference revealed for rework costs for project type and procurement. The ineffective use of indicating tools by design team members is the primary factor contributing to rework. The regression determined five significant independent rework cost predictors; viz., Ineffective use of IT by design team members, Lack of client involvement in the project, working procedures and communication lines, Changes made at the request of the client, Changes initiated by the contractor to improve quality.

Pauline Teo and John Morrison [14] explained quality failure costs, which are expressed in the form of non-conformance (NCRs) costs, were derived and analyzed for 218 projects. A total of 7,082 NCRs were categorized and quantified. It had shown that the contractors were required to bear the rectification cost of NCRs. Mean NCR cost as a proportion of a project's original contract value was 0.18%. Research provides the international construction community with invaluable insight into the real costs of quality failure due to rework. Fran Ackermann and Zahir Irani [15] performed research on rework in construction project revealed with the question- 'If a construction organization knows that rework is an issue in their projects, then why do they not put in place mechanisms to contain and reduce its occurrence?' It was found that construction organizations have limited understanding and knowledge of how rework manifests and its adverse consequences, on safety. It ensured that rework is a product of human error. Rework is hidden and unreported event because construction organizations have tendency to hide such incidents.

S. Chandrasha and Mehboob Basha [16] conclude that the rework is a problem which has to be faced in most of the construction industry and better understanding of the causes can assist the project managers to identify the methods to improve or eliminate rework. Additional time to rework and related extensions of supervising manpower were also identified. It also focused that rework leading to customer dissatisfaction and reduced profit. Ying Li and Timothy R. B. Taylor [18] proved that research work uses a system dynamic model of a two-phase project development cycle to minimize the impacts of rework and ripple effects on project development performance. It contributes to the existing body of knowledge by feedback description of how undiscovered rework impact project performance as well as in evaluating solutions to the problem. Failing to discover rework can magnify the impact of rework on project performance. To study the dynamics of change and its impact on project performance, a structured method specifies

the structure that creates changes. So that effective policies can be developed. This model is able to reflect situations and comparisons of different conditions as expected in a transportation construction project. The proposed model structure focuses on the impact of design phase on the construction.

### 3. Objectives

The overall objective of this research paper is to define the strategies for minimization of the rework for the improvement of construction productivity, performance and efficiency in the construction projects.

- To define the concept of the rework in construction project.
- To find the causes of rework in construction.
- To determine impact of rework on cost and time of project.
- To suggest rework mitigation strategies.

### 4. Questionnaire Survey

The research work for rework analysis is carried out through the questionnaire survey. For survey, respondents are selected by purposive sampling technique. Since collection of responses do not give assurance for uniform conclusions so that the non-probabilistic purposive sampling is selected for selecting respondents for questionnaire survey. Total sample size of this survey is taken as 50. Thus 50 respondents are asked to give response for survey by filling questionnaire provided through online Google form.

Questionnaire designed based upon the interviews conducted with contractors and engineers. After which sample questionnaire is designed and checked for review. Before proceeding towards survey, it was important to verify the appropriateness of the draft of questionnaire. For that purpose a rough questionnaire is prepared and checked from experts. Few amendments are made as a result of suggestions of them. Required corrections are also done and then final corrected draft of questionnaire is prepared. After this all essential corrections are carried out, through which final most relevant questionnaire is further circulated to 50 respondents randomly by online mode. Based upon the Likert scale, Relative Importance Index for all questions are calculated and based upon which severity of various parameters for rework is derived.

Questionnaire consists of four sections. The first section is about the profile of the respondents and nature of the construction projects in which respondents had faced incident of rework. Based upon their experience, this section is carried out for overall analysis of rework situations in construction project. Second section is determination of causes of rework in construction project. Total 12 main causes of the rework are selected and classified as human related causes, design related causes, and contractor related causes leads to rework occurrence. Third section gives analysis for rework impacts on

construction project. In last fourth section, rework analysis for selected construction activity which is nothing but concreting is performed.

**A. Profile of Respondents**

For analysis of the rework it is most essential to make analysis in classified manner based upon profession of the respondents in construction. Respondents working in different construction professions may have different experience, view and vision. Analysis of responses is made with classifying respondent’s profession.

In questionnaire survey, maximum 58% respondents are civil engineers. Along with them 10% of architects and 16% of both contractor as well as construction manager are contributed response for survey. Maximum 40% respondents having work experience in construction less than 5 years, while minimum 8% respondents have more than 20 years. Remaining 28% respondents have experience in between 5-15 years and 24% have experience in between 15-20 years.

**B. Project Characteristics**

Every respondent has faced at least once rework in construction in their past. The information related to that rework incidents are collected through survey. It is observed through survey that maximum 48% of construction projects were residential constructions, where rework occurred. 28% of commercial and 18% of industrial and 6% other projects was there.

54% responses have cost enhancement due to rework in 10-20% of total cost of construction. 20% of cases have cost increment in 20-30% of total cost of construction. Less than 10% of cost enhancement has 24% cases. Only 2% of responses have experienced more than 30% of cost enhancement. Duration of rework is also essentially considered. Only 2% of construction projects have delay less than 7 days. 48% projects have delayed in between 7-15 days; 42% projects are delayed 15-30 days. Remaining 8% have more than 30 days delay.

**C. Causes of Rework**

Causes of rework are considered according to the cause and effect diagram. Total 12 factors are considered as most relevant for occurrence of the rework in construction projects. All causes are classified as client related, design related and human resource related. Respondents were asked to give rating for severity of all factors in rework. After completion of survey, relative importance index (RII) is calculated for each response as shown in table 1.

According to the analysis made for determination of the severity of causes of rework in construction, supervision problem on construction site has maximum severity for rework occurrence while same for poor coordination of client in design work has minimum severity. In client related causes behind the rework, most severe parameter is poor communication between client and construction firm while lowest severity is observed in lack of knowledge about design of construction to client.

Error is the important source of rework. Here, in design procedure the error in technical things is highly contributing to rework in construction which is nothing but design related cause contributing to occurrence of the rework. Poor coordination of construction team in design procedure is less effective for occurrence of the rework in construction. Factors related to human resource in construction are having somewhat equal ratings and hence values of RII, so that human resource has to be essentially considered during deciding the rework mitigation and management program for any construction project.

Table 1  
Causes of Rework in Construction

S. No.	Causes of Rework	RII	Rank
1	Supervision problem	0.644	1
2	Unclear instructions	0.640	2
3	Improper training	0.632	3
4	Technical errors in design	0.612	4
5	Insufficient skill level	0.612	4
6	Poor communication	0.604	5
7	Lack of client involvement	0.604	5
8	Changes due to client	0.596	6
9	Lack of knowledge of design	0.576	7
10	Poor workload planning	0.572	8
11	Changes made by contractor	0.568	9
12	Poor coordination of design	0.400	10

**D. Impacts of Rework**

There are many impacts of one rework on one construction project. From literature survey, most important four parameters are selected and same parameters considered for questionnaire survey which is shown in graphically in figure 2. This analysis of relative importance index for impacts of the rework in construction is performed in same manner as that for causes of rework in construction. Most important four impacts of rework on construction are selected, which are time overrun, cost overrun, client dissatisfaction and disputes in client, contractor and other construction team. The most severe impacts are seen to be time and cost overruns. Both of these parameters have RII 0.688. Client dissatisfaction having RII 0.632, also lower severity is of dispute arrival because of rework incidents which is nothing but 0.556.

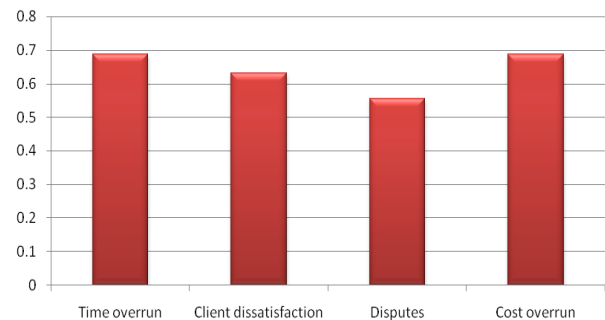


Fig. 1. RII for impacts of rework in construction

**E. Rework in concreting**

In construction project, the rework is an incident which may

happen in any activity out of which for research work concreting activity is selected. It is limited to the RCC works only. Total seven situations are selected related to the concreting activity in which rework is possible. Selected factors are based upon literature reviews as well as interviews carried out with contractors in preliminary data collection. Those factors have most possibilities to create a situation in which there is no any option remains other than rework. For such situations, it is seen that other remedial measures are not proven as more effective and efficient than rework. Table 2 shows the RII and ranking of the selected parameters for analysis of the rework in concreting; similarly, in figure 3, same thing is represented in graphical form.

In all selected parameters, the maximum value of RII is for displacement of the formwork in construction, which is worse situation for rework. Below which concrete mixing in wrong proportion and in wrong way are important for rework. RII for use of low quality steel in RCC work is seems to be lower than remaining factors. It means that up to minute level, steel quality can be compromised. But formwork material quality can never be compromised at any cost, because according to analysis, more several situations for rework in concreting are related with formwork material in the sense of their quality, handling and utilization method.

Table 2  
Rework in concreting

S. No.	Causes of Rework	RII	Rank
1	Displacement of formwork	0.712	1
2	Wrong proportion of concrete ingredients	0.696	2
3	Concrete mixing in wrong way	0.684	3
4	Leakage of concrete from formwork	0.676	4
5	Improperly fabricated formwork material	0.648	5
6	Appearance of cracks on concrete surface	0.600	6
7	Use of low quality steel	0.560	7

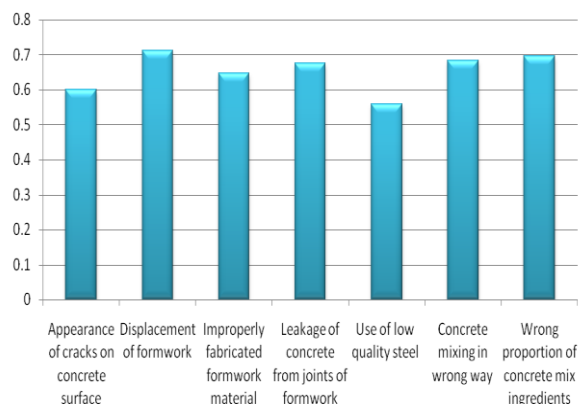


Fig. 2. RII for Rework in Concreting

### 5. Rework Mitigations

To reduce the frequency of rework and eliminate cost wasting and time delay due to rework the following precautions are recommended.

- Involvement of client in construction work should be lower. Extra influence of client leads to rework. But influence should be sufficient for proper understanding of the expectations of client from construction work. Proper communication with construction team and contractor is helpful for rework avoidance.
- Time cost management, material specifications, terms and conditions specified in contract document as well as drawings of design and plans should be properly checked and discussed with consultants for negotiation of the one important source of rework in construction which is nothing but error.
- Ongoing construction should be carefully supervised regularly. Quality of the material has to be verified before commencement of construction work. Rework if happened should be performed as smoothly as main course for reducing intensity of impact because of its occurrence.
- Human resource available for construction must be well trained and having at least minimum skills essential for construction. Workmen has to maintain communication with supervisor and site engineers for proper understanding of the task allotted to them as well as for solving the problems to which man force has to face during actual construction is going on.
- Preventing reworks to happen by considering the technical competency of the contractors. Most of the time the best contractor to select is not who offered the lowest price as there are hidden costs such as rework cost with them.
- Appropriate contractual safeguards are essential not only for obtaining the zero level rework but also to mitigate the other disputes. For development of such appropriate safeguards of contractual documents and recommended specifications as well as all standards, terms and conditions, suitable incentive mechanism is essentially to be developed and followed.

### 6. Conclusion

The research paper suggests that rework is a major problem in construction. Rework hampers the performance which results in quality degradation, time-cost overrun. For elimination of the rework, the better understanding of causes is essential. For which proper methodology is essential to be followed by management team. After completion of each activity, proper check mechanism is required. Supervision during the onsite construction helps in reducing the rework. Awareness and proper supervision helps in reducing overall rework. Lack of experience and knowledge of design, poor quality of construction technique are more responsible for rework in construction process.

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