

DEVELOPMENT OF FIELD REWORK INDEX TO MINIMIZE THE IMPACT OF REWORK FOR EFFECTIVE CONSTRUCTION WORK

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Abstract: The construction industry is facing significant problems of high cost of project delivery, bad financial performance and inability to deliver value to customers on time. A major factor contributing to this setback is rework. Rework is defined as the “unnecessary effort of redoing an activity that was inaccurately done the first time.” In essence, rework and wastages have become recognized as non-value adding endemic symptoms that seriously affect the performance and productivity aspects of construction projects.

From detailed literature review, total 53 factors that are causes of rework encountered in a construction project were identified and grouped into 7 categories. A questionnaire survey has been done to determine the most crucial factors by using Importance Index (IMPI) method with 160 respondents from south Gujarat region. After data analysis, misreading of drawings & specifications, scope of design changes, late designer input, change of plan and failure to implement quality management practices found to be most significant factors. In the final phase, from the survey crucial 14 factors were derived further they are used for generation of FRI (Field Rework Index). FRI will be now checked for its accuracy and to give warning to the construction firm that weather they are having chance of rework in their Construction work or not.

Keywords: Reducing Rework, Construction Cost Performance, Key Governing Factors, IMPI, Field Rework Index (FRI).

INTRODUCTION

Rework is a common occurrence in construction projects and has been identified as one of the factors that can degrade project performance. Over the years researchers have developed definitions and interpretations of rework in correspondence to their own production systems.

Rework in the construction industry as the “unnecessary effort of redoing a process or activity that was incorrectly implemented the first time.” The Construction Industry Institute (CII) defines field rework as “activities that have to be done more than once or activities that remove work previously installed as part of a project” (CII 2002). Rework in development projects can significantly degrade project cost and schedule performance. Research shows that rework in the construction phase could increase costs by 4% to 12% of the construction contract amount. The proportion of money and time spent on rework in the design phase is usually higher than that of the construction phase, as design is an iterative process during which engineers try to solve coupled problems with complex relationships. Sometimes design tasks are so closely related that each task, if not completed perfectly, has a probability of creating rework for another task. Under the pressure to improve project cost and schedule performance, many companies have accepted the fast-tracking approach under which the design phase and the construction phase overlap. Because of this phase overlap it is possible that a contractor can start the construction phase with flawed plans that have undiscovered errors (referred to as “design undiscovered rework” in the current work). In large, complex projects undiscovered rework in the design phase can produce a significant amount of rework in the construction phase.

IMPORTANCE OF REDUCING REWORK

From many reported cases it could be affirmed that rework have negative impact on the performance of projects in term of cost overrun, time overrun and dissatisfaction of the participants on the project. Impacts are enormous on project; the direct impact of rework on project where it is identified consists of; additional time to carry out the rework, additional cost to rectify the occurrence, more materials for rework and wastage, and consequential increase in labour cost to fix the defect plus related extensions of manpower supervision. Hence, if rework is to be reduced or avoided there is need for clients’ initiating a construction activity to reduce changes or alteration to design after commencement of work. It was reported that the actual cost of rework for a contractor may actually be less than one percent of a contract value and that a contractor will invariably always try and off load any additional costs on to their client and subcontractors. In fact a contractor’s estimate/tender figure may also allow for some degree of rework (in the form of a contingency) based on their knowledge and experience from previous and similar projects that they have undertaken. Thus the actual cost of rework to a contractor may even be negligible, especially projects

procured under a design and construct arrangement with a guaranteed maximum price. Earlier studies have shown that rework costs vary between 3 and 15% of project’s contract value (Burati et al., 1992; Abdul-Rahman, 1997; Josephson and Hammurlund, 1999). In addition, Rethinking construction, 1998 in Aminudin (2006) stated that: up to 30% of construction is rework, labour is used at only 40 to 60% of potential efficiency and at least 10% of materials are wasted. It was posited that rework costs could be significantly higher than figures reported in articles relating to standards (Love and Smith, 2003). Indeed, Barber et al. (2000) suggested that rework costs could be as high as 23% of the contract value.

THE EFFECT OF REWORK ON CONSTRUCTION COST PERFORMANCE

The CII Capital Program benchmarking and metrics program collected data for approximately 360 projects where direct rework costs were measured as a portion of actual construction costs. CII developed a formula to calculate a metric known as Total Field Rework Factor (TFRF), which is expressed as Total Direct Cost of Field Rework over the Total Construction Phase Cost as a leading indicator used for this group data analysis. The data samples were split into two groups, one for Owners and one for Contractors, with the results being analyzed separately for each group.

Formula for Total Field Rework Factor:-

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$$TFRF = \frac{\text{Total direct cost of field rework}}{\text{Total construction phase cost}}$$

The TFRF formula can be used with each of the sources of rework to identify the highest impact on cost performance. CII’s research team also developed a field rework questionnaire index to help identify the need for rework early on in projects, which serves as a performance indicator with the objective of reducing rework and ensuring the intended purpose could be completed before the start of construction.

METHODOLOGY

A three-stage research methodology was adopted: First, detailed literature survey to identify causes of rework in construction projects. Second, a questionnaire survey was adopted to evaluate and rank these factors. The questionnaire survey was conducted in Surat city of south Gujarat region with site engineers, contractors, owners’ labours and designers. In the final stage, from the survey crucial 14 factors were derived further they are used for generation of FRI (Field Rework Index). FRI will be now checked for its accuracy and to give warning to the construction firm that weather they are having chance of rework in their Construction work or not.

CAUSES RELETED TO REWORK

There are various causes of rework that are knowingly & unknowingly affect the construction projects. I carried out a comprehensive analysis of relevant available literature to classify and highlight the most crucial causes that affect the construction projects (Table 1). The parameters for rework are then classified into seven broad.

Table 1: Causes of Rework

Main Factor	Sub Factor	Main Factor	Sub Factor
RELATED TO DESIGN	Scope & design changes	RELATED TO MATERIAL	Untimely deliveries
	Poor project document		Non-compliance with specification
	Incomplete information		Materials not in right place when needed
	Improper planning		Adulterated materials
	Software error/mistake		Invalidity of needed
	Qualification of designer		Emergency conditions (siege & closures)
RELATED TO CONTRACTOR	Misreading of drawings & specifications		Change in material
	Low contract value	Class of material	

	Attempts to fraud		Maintenance issue relevant to material
	Unqualified technically		Lack of knowledge of construction process
	Financial weakness		Inadequate briefing
RELATED TO EXTERNAL ENVIRONMENT	Political situation (Siege- conflicts)	RELATED TO OWNER	Lack of funding allocated for consultation
	Economy (Inflation, exchange rates, market)		Changes because of change in officials
	Natural climates (Weather, disaster)		Need early completion of work
	Physical conditions (Infrastructure, transportation, etc)		Change of plan
	Inadequate local education		Improper supervision
	Social (Changing social environment, resistances)		Failure to implement Quality management Practices
	Technological (techniques, facilities, machines)		Rigidity to improvement
RELATED TO HUMAN RESOURCE CAPABILITY	Excessive overtime	RELATED TO CONSTRUCTION PROCESS	Absence of clear uniform standard to accept work
	The absence of job security		Unclear work specification
	Lack of employee motivation and rewards		Inadequate pre-project planning
	Insufficient training and skill development		Constructability problems
	Unclear line of authority and responsibility		Lack of Audit and control
	Conflict of interest		Schedule pressures
	Lack of safety and welfare commitment		Late designer input
			Not hire project manager for work
Lake scheduling of work			
			Selection of wrong method

DATA ANALYSIS & RESULTS

The primary data collected from the first part of the questionnaire was analysed from the perspective of total 160 respondents comprise of owner, site engineer, labour, designer and Contractor. The responses of them were taken for the analysis with the help of Importance Index (IMPI) method. The top 14 factors derived from result are shown below in table 2.

Table:-2 Top 14 Factors from IMPI Method

SR NO.	C.NO.	CAUSES OF REWORK	S.I	F.I	IMPI
1	C1	Misreading of drawings & specifications	67.81	62.19	42.1708
2	D1	Scope & design changes	67.03	62.66	41.9998
3	CP1	Failure to implement Quality management	66.09	61.41	40.5856
4	O4	Changes because of change in officials	59.38	67.50	40.07812
5	CP9	Late designer input	62.50	63.91	39.9414
6	O6	Change of plan	69.06	57.19	39.4951
7	O7	Improper supervision	64.38	58.75	37.8203
8	M9	Maintenance issue relevant to material	57.97	62.81	36.4116
9	M2	Non-compliance with specification	60.94	59.69	36.3720
10	M1	Untimely deliveries	55.47	64.69	35.8813
11	CP7	Lack of Audit and control	56.41	62.81	35.4301
12	CP2	Rigidity to improvement	61.56	53.13	32.7050
13	O1	Lack of knowledge of construction process	56.56	61.56	34.8212
14	CP8	Schedule pressures	58.75	58.44	34.3320

REWORK INDICES

Several indices related to rework measurement were reviewed. These indices are listed in Table-3 and are described in the following sections.

Table:-3 Rework Indices Reviewed

Doc	Description Source
FRI	Field Rework Index CII
PDRI	Project Definition Rating Index CII
PRRT	Project Rework Reduction Tool COAA
QPMS	Quality Performance Management System CII

THE FIELD REWORK INDEX - FRI

The FRI is a tool developed by Research Team 153 of the CII (Rogge et al. 2001) to provide an early warning if a project is headed towards high levels of field rework. The FRI is intended for use before the start of construction.

To develop the FRI, a list of possible predictors of field rework was first developed and tested with data taken from construction projects. This information was obtained via a questionnaire survey of a number of building projects. The database, consisting of rework measurements, subjective ratings, and project variables identified as potentially related to field rework, was then developed based on the findings of the questionnaire survey.

An analysis was carried out to determine how these variables related to field rework. The Field Rework Index (FRI) resulted from statistical analysis of the database. The research team was able to determine that significant relationships existed between field rework and certain project variables and parameters studied. The FRI questionnaire and rework danger chart are given in below.

Table 4:- Sample Tabular Format of Field Rework Index

Table:- Rework Questionnaire Index					
	Questionnaire	Answer (option)	Score	Answer (option)	Selected Score
1		Could not be better	1 2 3 4 5	Could be worse	
2		Completely	1 2 3 4 5	Not at all	

3		Could not be better	1 2 3 4 5	Could not be worse	
4		No change at all	1 2 3 4 5	Continual change	
5		Could not be better	1 2 3 4 5	Could not be worse	
6		Could not be better	1 2 3 4 5	Could not be worse	
7		Could not be better	1 2 3 4 5	Could not be worse	
8		Could not be more available	1 2 3 4 5	Could not be less available	
9		Not compressed at all	1 2 3 4 5	Could not be more compressed	
10		None	1 2 3 4 5	Very high level	
11		Could not be lower	1 2 3 4 5	Could not be higher	
12		Total Commitment	1 2 3 4 5	Total lack of commitment	
13		Readily available	1 2 3 4 5	Very scarce	
14		None	1 2 3 4 5	Very high level	

Source: (CII, 2001)

CII’s questionnaire Field Rework Index (FRI) and rework chart are found in Table and Fig. All answers with a rating of 1 receive 1 point; all ratings with a rating of 2 receive 2 points, and so on through to a maximum of 5 points. The score for each question is then added together to give a total score; those with a score between 14 and 70 are grouped according to the FRI score categorizing chart. Those scoring higher than 45 are classified as being within a Rework Alert stage.

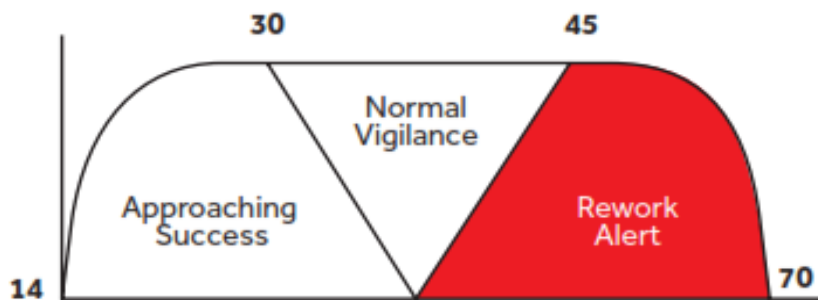


Figure: - FRI Score Chart

Source: (CII 2001)

CONCLUSION & RECOMMENDATIONS

It is very important to document rework events in the project, and it’s strongly recommended to have a control system to rework. That can be implemented by increasing project parties’ awareness about rework and well understanding to causes of rework. This issue will assist project managers to identify the best methods to improve the performance of contractors to minimize rework. The preliminary study indicates that the listed factors affecting project performance must be given adequate consideration while taking decision of new projects. Misreading of drawings & specifications, Scope & design changes, Failure to implement Quality management, Changes because of change in officials, Late designer input, Change of plan, Improper supervision, Maintenance issue relevant to material, Non-compliance with specification, Untimely deliveries, Lack of Audit and control, Rigidity to improvement, Lack of knowledge of construction process and Schedule pressures are most significant factors

for rework. So these factors must be taken consideration. Proposed field rework index is validated with the on-going and completed 30 building projects and results are very satisfactory. FRI will be now checked for its accuracy and to give warning to the construction firm that weather they are having chance of rework in their Construction work or not.

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