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A REVIEW ON:-FIELD REWORK INDEX TO MINIMIZE THE IMPACT OF REWORK IN CONSTRUCTION INDUSTRY

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Abstract: ***Construction projects are complex in nature because they entail complex activities characterized with uncertainties and changes that are capable of increasing time and cost of construction projects. Rework is a waste that involves doing certain task more than once, it may not be totally eliminated but it is avoidable. It occurs as a result of so many factors ranging from omission or error in design, construction failure, and change order to inadequate coordination and communication among stakeholders on the project.*** *Rework as the "unnecessary process of redoing a work activity that was incorrectly carried out the first time."* ***Hence, to enhance project performance it becomes imperative to identify the influence of project type on the occurrence of rework .The paper reviews the current status of rework in the construction industry through reviewing the previous literature .This includes first the correct meaning of term rework through the evolution of various definitions stated by different researchers. Secondly the sources or causes of rework are reviewed. For all sources design change and construction change are two main categories found contributing mostly to rework. Third thing is the impact of rework on construction projects reviewed and found that cost and schedule overruns are two areas mostly affected. About 5-12% increase in cost of total projects is seen. However this percent varies accordingly with different researchers. Finally a review is made on reducing the rework in projects and found that continuous improvement, benchmarking, audits plays an important role in reducing rework. In that the rework reduction tool that field rework index (FRI) is developed for effective construction work.***

Keywords: Construction Industry, Construction Cost Performance, FRI, Reducing Rework, Rework

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.

Rework Indices

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

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 completed construction projects. This information was obtained via a questionnaire survey of a number of industrial 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 industry 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. Table is a list of the project variables (14) related to field rework and ranked in descending order.

Table:-Variables with Statistically Significant Relationships with Field Rework

FRI Variable	Relations ip
Owner alignment	Strongest ↓ Weakening ↓ Weakest
Design rework	
Constructability commitment	
Interdisciplinary design coordination	
Degree of project execution planning	
Design firm's qualifications	
Field verification	
Expected craft worker availability	
Expected construction overtime	
Engineering overtime	
Design leadership changes	
Design schedule compression	
Supplier pre-qualification	
Supplier information	

Source: Rogge et al. (2001)

FRI Score	% of Projects with "High" or "Very High" Rework	% of Projects with "Low" or "Very Low" Rework	Rework Rating Average 1=Very Low 5=Very High	Mean Measured Rework (%)
>45	65% (13/20)	25% (5/20)	3.6 = High	6.8% (16
30-45	32% (24/74)	42% (31/74)	2.8 = Medium	5.0% (53
<30	2% (1/43)	86% (37/43)	1.8 = Low	2.5% (34

The following table presents the summary statistics from the project database from which the FRI is derived. The FRI questionnaire and rework danger chart are given in below.

The results of the regression analysis concluded that it was not possible to predict a percentage of field rework via the FRI, but, rather, the FRI proved to be a simple tool providing early warning for field rework and cost growth.

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:-

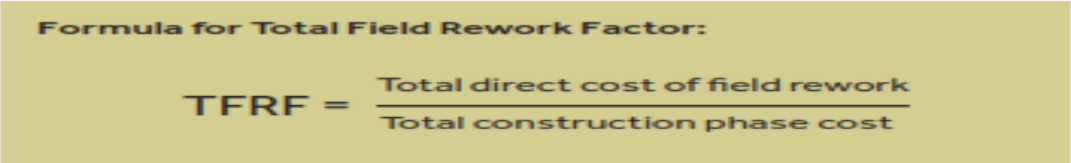

Table 1.0 Rework Questionnaire Index

	Questionnaire	Answer (option)	Score	Answer (option)	Selected Score
1	Degree of alignment between various elements of the owners organization (departments, divisions)	Could not be better	1 2 3 4 5	Could be worse	
2	Degree to which project execution planning was utilized	Completely	1 2 3 4 5	Not at all	
3	Design firm's qualifications for the specific project	Could not be better	1 2 3 4 5	Could not be worse	
4	Degree to which leaders of key design disciplines have changed	No change at all	1 2 3 4 5	Continual change	
5	Quality of field verification of existing conditions by engineering	Could not be better	1 2 3 4 5	Could not be worse	
6	Quality of interdisciplinary design coordination	Could not be better	1 2 3 4 5	Could not be worse	
7	Quality of prequalification of vendors for the project	Could not be better	1 2 3 4 5	Could not be worse	
8	Availability of vendor information for equipment	Could not be more	1 2 3 4 5	Could not be less available	
9	Degree to which design schedule is compressed	Not compressed at all	1 2 3 4 5	Could not be more compressed	
10	Level of overtime worked by the engineering	None	1 2 3	Very high	
11	Level of design rework (repeating design work)	Could not be lower	1 2 3 4 5	Could not be higher	
12	Commitment to constructability of the design and construction team	Total Commitme	1 2 3 4 5	Total lack of commitment	

13	Expected availability of skilled craft workers to the project	Readily available	1 2 3 4 5	Very scarce	
14	Expected level of construction contractor overtime	None	1 2 3 4 5	Very high level	

Source: (CII, 2001)

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.

CII's questionnaire Field Rework Index (FRI) and rework chart are found in Table 1.0 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.

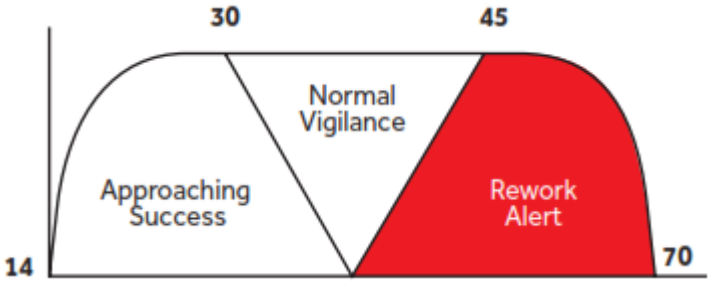

Fig. FRI Score Chart

Source: (CII 2001)

CASE STUDY ON: CONSTRUCTION OF CHILDREN AND DELIVERY HOSPITAL

Background

This case illustrates a vital and important project in the Gaza Strip, this project composed of two stages; first stage was construction stage, and the second was furnishing and equipment's stage. The expected cost of this project is more than 10 million U.S. dollars. This case studied the first phase of the project (construction stage), which consisted of concrete and finishing work. The building consists of three floors; (underground floor + ground floor, first floor) each floor area about 1200.00 m2 with complete finishing work. The project includes landscape works about 2000.00 m2. Project funding worth about 4 million U.S. dollars.

About 100 people worked in this project. 20 skilled and 25 unskilled worker implemented concrete and blocks work. 40 skilled workers implemented finishing work, and number of semi-skilled electro-mechanic workers. Air-conditions work was new and there was little experience in mechanism of instillation it in Gaza Strip. In addition to that the contractor supervision team was consisted of 10 years' experience project manager, nine years' experience site engineer, fresh graduated site engineer, 20 years' experience mechanic engineer and 20 years' experience electric engineer.

In the other side consultant team was consisted of, 25 years' experience project manager worked as part time, 10 years' experience site engineer and fresh graduated site engineer who worked as full time, 17 years' experience mechanic engineer and seven years' experience and electric engineer worked as part time. In addition to that the owner of the project employed

an architect as a site engineer in the project, and part time supervision from two electro-mechanic engineers who worked for the owner.

Main Rework

The researcher looked on project documents and reports and visited the project and made a number of interviews with the director of the project, owner, beneficiary representatives, contractor and the consultant. Several cases of rework were noted.

This rework cases has been recorded for this study in terms of its main causes, its impact on project cost and time, which party took the responsibility of that rework. Table summarize main characteristics of the project of the case study.

Table: Main characteristics of the project of case study

Project name	Construction of Children and delivery hospital (phase 1)
Project Location	Middle of Gaza Strip (Dier-AlBalah city)
Donor	Islamic Development Bank (IDB) and Jordanian Authority for Gaza reconstruction.
Owner	Ministry of Health
Designer	Al Baha design office from Jordan
Consultant	A consultant company (Engineering and management consultant company EMCC)
Contractor	First class A contractor (Osama Khail company)
Type of contract	Traditional contract (Unit price)
Planned budget	4 million U.S. dollars.
Contract Value	3,899,835.72 U.S. dollars.
Actual project cost	3,900,000 U.S. dollars.
Cost overrun	Non , there will be other phase in the project about 6 million U.S. dollars.*
Planned duration	15 month
Actual duration	24 month
Time overrun	9 months
Extensional duration	5 months (agreed extension between project parties)
Unsatisfied delay	4 months, the contractor carried all delay consequences
Overhead cost	8% total project cost , about 433 U.S. $ / day
Delay penalties	About 1,950 U.S. dollars per day

There was no-cost overrun because, available fund for this stage of the project was limited and there will be another stage. So that overrun cost was at the expense of other activities' cost, which was postponed to later stages of the project.

CONCLUSION

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. Qualified contractor with suitable contract price will increase the efficiency of project performance and will contribute effectively to reduce rework. It’s strongly recommended to increases the interest of human-resource where its impact cannot be denied

on the rework. Efficient supervision and leadership, skills labour force and effective team work are very important measures to minimize rework. Coordination, integration, employee involvement, strengthen personnel internal ethics, job security, Commitments to safety (by applying strict laws), minimization work stress and effective communication are essential in construction project and very helpful factors which decrease rework.

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