

REDUCING REWORK TO ENHANCE PROJECT PERFORMANCE LEVELS

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Rework in construction projects is referred to as the unnecessary effort of redoing a process or activity that was incorrectly implemented in the first instance. In construction projects, rework can result from an array of factors such as errors, omissions, failures, changes, poor communication and poor coordination. Rework could adversely affect the performance and productivity and ultimately the profit margins as well. For example, some previous studies identified that costs of rework could add around 10% to the total project costs. However, the literature also suggests that rework is mostly unnecessary and avoidable. A pilot study is being conducted in Hong Kong to explore the rework occurrences in the local construction industry. In this paper, some discussions regarding the significance of reducing rework and an overview of rework factors are presented. Also, a structured framework for rework management has been proposed so as to enhance the project performance levels.

INTRODUCTION

The construction industry is mainly project-based and various complexities are inherent in the construction projects e.g. dealing with diverse interests of multiple stakeholders and resultant changes/ variations. Mainly, rework and wastages are considered as non-value adding endemic symptoms that seriously affecting the performance and productivity aspects in construction projects (Alwi et al. 2002, Josephson et al. 2002). The rework occurrences in construction projects are mostly from the unnecessary redoing/ rectifying efforts of incorrectly implemented processes or activities (Love, 2002). The critical tasks of project managers include balancing the competing demands of quality, scope, time and cost (PMI, 2004). Thus, project management roles can provide effective fulcrum for tracking of rework occurrences and thereby implementing suitable management measures for reducing the resultant impacts on productivity and project performance.

Although changes may be deemed as inevitable in some perspectives, uncontrolled occurrences of rework and wastages should be effectively controlled to improve various targeted objectives of construction project management e.g. with respect to timeliness, cost targets and product/ service quality. A pilot study is being conducted in Hong Kong that mainly aims at (a) identifying significant rework items and their root causes in the construction projects and (b) developing structured frameworks for effective rework control and management. This paper presents (a) a basic summary of significance of reducing rework, (b) an overview of rework factors, and (c) a proposed framework of rework management to enhance project performance levels. For brevity, the complete details of ongoing rework study are not covered in this paper.

SIGNIFICANCE OF REDUCING REWORK

Rework occurrences adversely impact the project performance aspects e.g. with respect to costs, time, stakeholder satisfaction. The direct impacts of rework on project management transactions include (a) additional time to rework, (b) additional costs for covering rework occurrences, (c) additional materials for rework and subsequent

wastage handling, (d) additional labour for rework and related extensions of supervision manpower. Previous studies indicated that the costs of rework in poorly managed projects can be as high as 25% of contract value and 10% of the total project costs (e.g. Barber et al, 2000, Love and Li, 2000). For example, the Construction Task Force in UK reported that up to 30 percent of construction is related to rework (Egan, 1998) and the USA based Construction Industry Institute has estimated that the annual loss due to rework could be as high as US\$ 15 billion for industrial construction projects (CII, 2001a). Rework is a significant contributor to time wastage and time/schedule overruns (Kumaraswamy and Chan, 1998; CII, 2001b), which will eventually impact on costs (e.g. indirect costs such as overheads), resources and quality as well (Love et al 2004). Rework also triggers claims for extra costs and time wasted in redoing or repairing, given that contractors for example, would seek some form of compensation from those they may consider responsible, wherever possible (Palaneeswaran et al. 2006). Table 1 provides a basic summary consolidated from a set of previous studies on rework.

Table 1: Some extracts of rework impacts from different studies

Source	Impacts on project performance
Barber et al. (2000)	<ul style="list-style-type: none"> This UK based study examined the quality failure costs in two highway construction projects (procured using Design-Build-Finance-Operate). The quality failure costs were 16% and 23% when the costs of delay were also included. If the costs of delay were excluded, the corresponding quality failure costs were 3.6% and 6.6%.
Josephson et al. (2002)	<ul style="list-style-type: none"> The cost of defects identified from seven building projects in a Sweden based study ranged between 2.3% to 9.3% of contract value In another Sweden based study, the quality failure costs were found to be 6% of original contract value
Fayek et al. (2003)	<ul style="list-style-type: none"> From the 108 field rework incidences in a Canada based study, the following findings were derived as cost contribution summary: (a) Engineering & Reviews – 61.65%; (b) Human Resource Capability – 20.49%; (c) Materials & Equipment Supply – 14.81%; (d) Construction Planning & Scheduling – 2.61%; and (e) Leadership & Communication – 0.45%.
Rhodes and Smallwood (2003)	<ul style="list-style-type: none"> In a South Africa based study, the cost of rework was found to be 13% of the value of completed construction In the same article it was reported that a research conducted by the Associated General Contractors of America found that the average cost of rework (from nine industrial projects) was 12.4% of the project cost
Love and Edwards (2004)	<ul style="list-style-type: none"> Construction Industry Development Authority in Australia found that average cost of rework in projects without a formal quality management system is 6.5% of contract value (and the high value for a project under lump sum procurement was 15%). However, the average cost of rework for projects with a quality system was found to be 0.72%. In another Australia based study (Love, 2002) 161 projects were studied and the mean of direct and indirect rework costs were found to be 6.4% and 5.6% of the original contract value, respectively. However, this study revealed that project procurement type may not have significant influence on the rework costs
Marosszeky (2006)	<ul style="list-style-type: none"> In this Australia based study (in New South Wales), the rework costs on the average were found as 5.5% of contract value, that include 2.75% as direct costs, 1.75% indirect costs for main contractors and 1% indirect costs for subcontractors.

Some notable cases observed from the ongoing Hong Kong based pilot study:

- In one sampled private building project (new construction works for \$60 millions), the direct costs of rework was found to be 16.1% of original contract value and the corresponding figure for indirect costs was 4.8%. The time overrun in that project was 277 days, for which the original period (i.e. at the award of contract) was 480 days
- In another sampled private building project (new construction works for \$290 millions), the direct costs of rework was found to be 3.5% of original contract value and the corresponding indirect costs was 1.7%. In this project, these rework costs were shared by the client, contractor and subcontractors as follows: (a) clients – 2% direct costs and 1% indirect costs, (b) main contractor – 1% direct costs and 0.5% indirect costs, (c) subcontractors – 0.5% of direct costs and 0.2% of indirect costs. The time overrun in this project was 2 months, for which the original period was 24 months.

In addition to the direct impacts (i.e. with respect to time, cost, and resources) on specific activities/ tasks, the rework occurrences will often have some indirect impacts subsequently (e.g. on several other related activities/ tasks). Thus, in poorly managed projects, the gross impacts of rework (i.e. direct and indirect rework impacts) could be equal to or even exceed the anticipated ‘mark-up’/ profit margin levels. Also, in some cases there will be some ‘carry forward’ ripple effects on different aspects such as stress, motivation, relationships and reputation. Above all, the consequences of such ripple effects and intangible damages could be more serious than the tangible/ measurable items. Furthermore, such ‘carry forward’ impacts will enhance the bid price levels (e.g. in future projects) and any undetected or lately detected rework problems could be even more serious to all the stakeholders in a construction project.

Significant ‘tacit’ observations consolidated in this research (i.e. from interviewing of some experienced senior level industry practitioners) include:

- A number of potential rework items (such as those due to quality deviations) are mainly dependent on the knowledge/ awareness levels of the stakeholders (e.g. clients)
- To some extent, the level of rework in construction projects would be depending on the external factors such as excessive workload and market conditions (e.g. increased defects and poor workmanship may arise from limitations on the availability of good subcontractors/ workers, additional/ unwarranted pressures for early completion, etc.)
- Compared to civil works, more number of rework occurrences can occur in building works due to reasons such as different interface related management issues (e.g. lack of coordination between building contractors and building services contractors, poor communication between design team and construction team).
- Timely identification and rectification of rework (e.g. due to construction defects, design errors and other non-conformances) are crucial for controlling the adverse impacts of rework (e.g. on costs and time). Systematic documentation is necessary for any related recovery measures (e.g. from subcontractors). Above all, some portion of the rework costs (e.g. part of indirect costs) may be deemed as unrecoverable/ loss.

OVERVIEW OF REWORK FACTORS

In general, rework could arise from various sources such as changes, damages, defects, errors, failures, omissions, and other non-conformances/ quality deviations. The root causes of rework can be categorized into different groups such as client-related factors, design-related factors, and contractor-related factors including site management and subcontractor factors (Love and Edwards, 2004). A basic overview of some such rework factors is provided in this section.

Mainly, the client based rework symptoms are from design and construction related sources such as the design changes made at the request of clients and the construction related changes initiated by clients i.e. both (a) after some work had been undertaken on-site, as well as (b) when a product/ process had been completed. The client-related rework factors include: (i) lack of experience and knowledge of design and construction process, (ii) lack of funding allocated for site investigations, (iii) lack of client involvement in the project, (iv) inadequate briefing, (v) poor communication with design consultants, and (vi) inadequacies in contract documentation

Moreover, previous studies indicated that significant part of rework is design-related (e.g. Love, 2005). The design related rework symptoms are such as changes made by different parties (e.g. clients, contractors/ subcontractors, end-users/ regulatory bodies), errors and omissions (e.g. in the contract documentation process). The design-related rework factors include: (i) ineffective use of quality management practices, (ii) ineffective use of information technologies, (iii) poor coordination between different design team members, (iv) time boxing/ fixed time for a task, (v) poor planning of workload, (vi) lack of manpower to complete the required tasks, (vii) staff turnover/ re-allocation to other projects, (viii) incomplete design at the time of tender, (ix) insufficient time to prepare contract documentation, and (x) inadequate client brief to prepare detailed contract documentation. Figure 1 portrays an influence diagram of design related rework symptoms in construction projects.

The subcontractor related factors that might cause rework include damages, defects, poor workmanship, inadequate managerial/ supervisory skills, use of poor quality materials and specific problems associated with multi-layered subcontracting. Other symptoms and rework factors include constructability associated concerns, poor site conditions and other environmental parameters - e.g. setting out errors, failure to provide protection to constructed works, changes in construction methods to improve constructability, errors due to inappropriate construction methods, omission(s) of some activity or task.

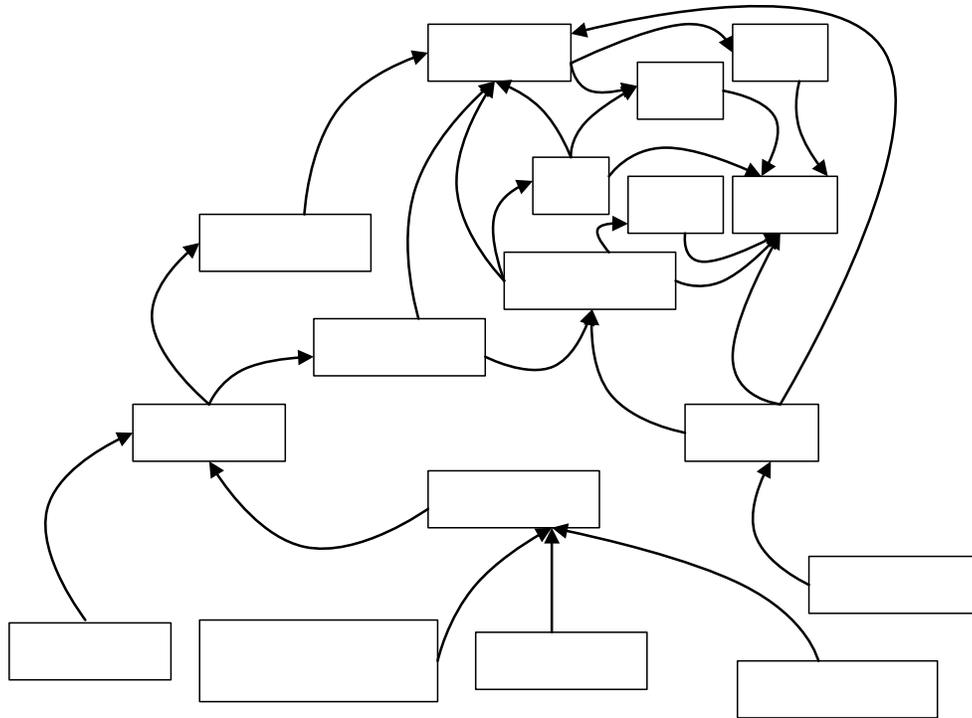


Figure 1: Influence of design related rework symptoms

MANAGEMENT OF REWORK IN CONSTRUCTION PROJECTS

In project-based transactions, any occurrence of rework is mainly considered as unnecessary/ redundant non-value adding item (Love et al. 1999) that should be mostly avoided if not completely eliminated. The observations from the ongoing Hong Kong based rework research (e.g. Palaneeswaran et al. 2005a) indicated that there had been no systematic approach specifically followed for monitoring rework occurrences and their impacts in the Hong Kong construction projects. Apparently, the rework impacts on performance and productivity aspects have been somehow ‘tackled’ by adopting various tactics and measures such as through contract management, quality management, project management, and value management.

In addition, different ‘push’ and ‘pull’ strategies have been followed in the construction industry – such as implementing appropriate risk management mechanisms in the supply chain (e.g. sharing/ transferring/ pricing of risks) and considering compensable recoveries from other parties e.g. through contractual claims. Figure 2 portrays some such sample patterns observed in the ongoing rework research. However, instead of following any ad hoc measures, rework reduction and/or elimination should be targeted for enhancing the sustainability of profitability in contractor organizations.

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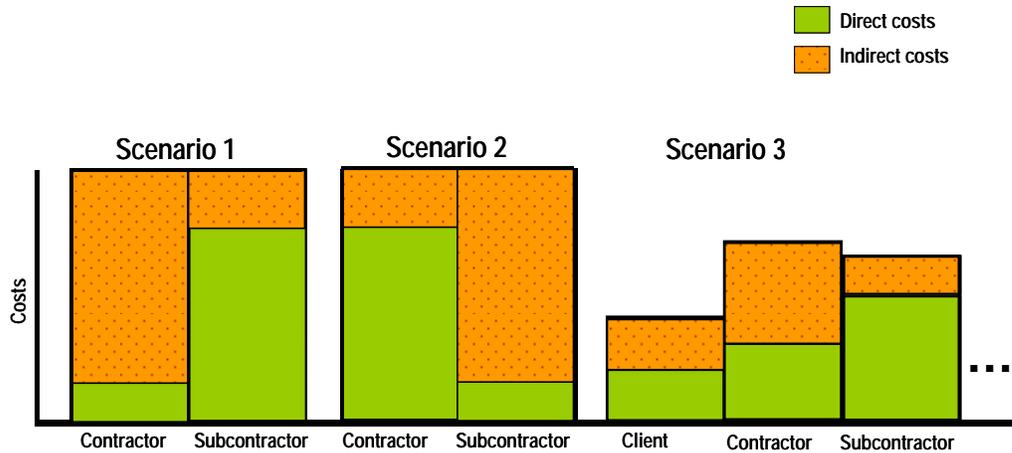


Figure 2: Sample scenarios of sharing the rework costs

Although some innovative approaches and management fads (e.g. partnering, relational contracting, supply chain management) have been extensively used as overriding reinforcements in construction projects (Palaneeswaran et al. 2003), a systematic approach (e.g. for identifying the root causes of rework) and structured tracking mechanisms are essential for effectively tackling the rework related inefficiencies (Love and Edwards, 2004) and most of the resultant ripple impacts e.g. delays and disruptions, lowered productivity, incurrence of additional costs and resources (such as material wastages and their handling charges), adversarial conflicts, claims and disputes, and damaged reputation and goodwill. Figure 3 portrays a basic framework (Palaneeswaran et al. 2005b) proposed for systematic management of rework occurrences in construction projects.

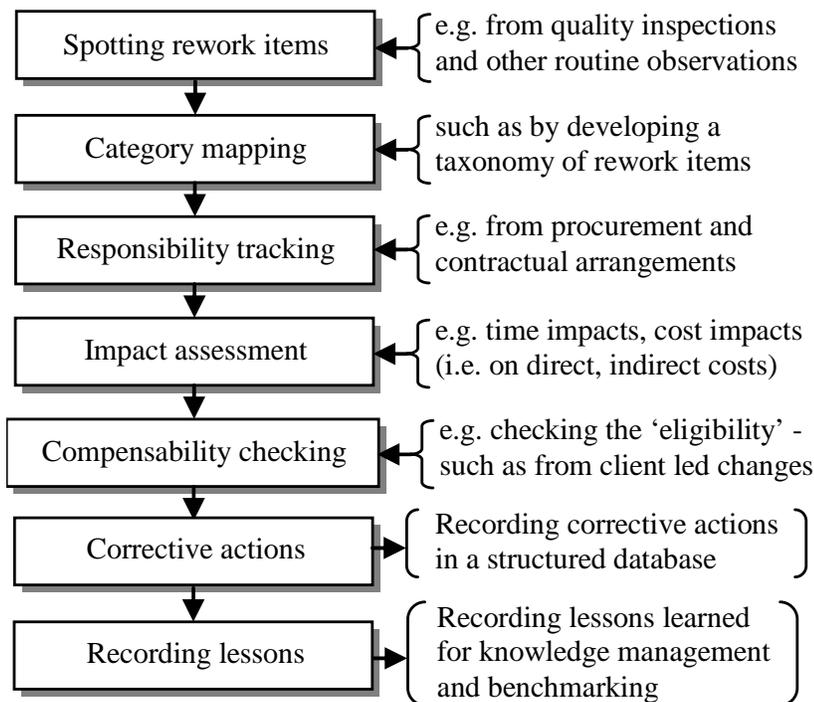


Figure 3: Proposed framework for managing rework in projects

The main transactions of this proposed management framework include (a) identifying rework occurrences, (ii) systematic mapping using a taxonomy and ontology based classification of rework items, (iii) responsibility tracking for each rework occurrence, (iv) impact assessment (e.g. on costs, time and client satisfaction), (v) compensability checking (e.g. for contractual claims and recovering from subcontractors), (vi) recording of lessons learned for knowledge management and benchmarking.

Appropriate root cause analyses for reducing of rework should be targeted by developing suitable feedback and feed-forward knowledge networking mechanisms. For example, from the root cause analysis of 125 field rework incidences in a Canada based study that used a ‘Field Rework Data Collection System’ (Fayek et al. 2003), the following findings were derived as frequency of occurrence: (a) Engineering & Reviews – 55.41%; (b) Materials & Equipment Supply – 23.46%; (c) Human Resource Capability – 18.28%; (d) Construction Planning & Scheduling – 2.47%; and (e) Leadership & Communication – 0.38%. Such categorized break-up information and further analyses will be useful for (a) effecting appropriate management measures in the current projects as well as (b) targeting improvement measures in future works.

Figure 4 portrays a knowledge management and benchmarking framework for value networking and enhancing performance levels in construction projects (Palaneeswaran et al. 2005c). Accordingly, structured systems (e.g. tracking procedures and documentation frameworks) and systematic practices should be developed for progressing through knowledge discovery (e.g. from data mining) and further advancing from corrective measures and benchmarking targets.

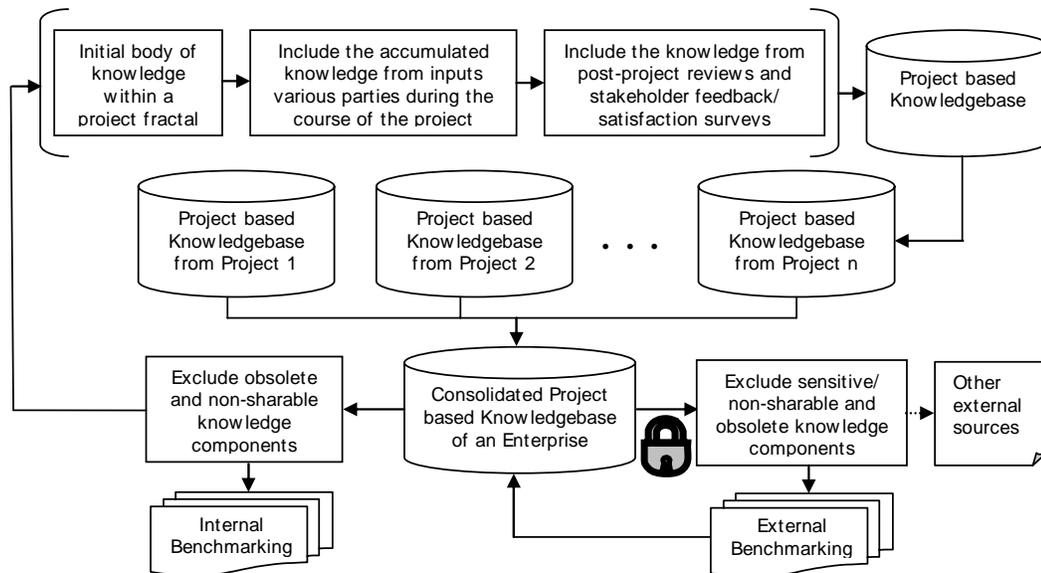


Figure 4: Project based knowledge networking and benchmarking

Above all, recommended strategies for **Zero Rework** should embrace the following eight overlapping channels:

1. Avoiding defects, errors, omissions, non-conformances and other quality deviations (e.g. through appropriate supervision and quality management systems)

2. Reducing changes and adversarial conflicts (e.g. through enhanced stakeholder interactions and early involvements, improved scope definitions including freezing from further changes, etc.)
3. Enhancing systematisation including improved documentation, information and communication arrangements
4. Selecting best value business partners such as (i) knowledgeable and understanding clients – including continuous monitoring of their satisfaction levels, and (ii) best possible supply chain sources e.g. subcontractors and suppliers – including continuous monitoring of their performances (e.g. through key performance indicators) as well as motivation levels (e.g. through structured queries/ surveys)
5. Adopting appropriate contractual safeguards and developing suitable incentive/ disincentive mechanisms
6. Reinforcing relationships and enabling better supply chain integrations
7. Championing relevant advanced construction technologies (e.g. modularisation/ standardisation, pre-cast/ prefabricated components, robotics and other automation)
8. Learning and training arrangements (e.g. through lessons learned frameworks, success and failure stories)

SUMMARY AND CONCLUSIONS

Uncontrolled rework occurrences in construction projects have serious impacts on project performance. However, the endemic rework occurrences as well as their impacting influences performance and productivity aspects should not be viewed as inevitable. The undesired outcomes related to rework can be substantially improved through developing of adequate awareness as well as structured systems for rework management.

The observations from the ongoing Hong Kong based rework study identified that the costs and other impacts of rework are rarely tracked in construction projects. However, the resultant inefficiencies and other ill effects of rework are apparently nullified/ reduced (or at least made partly/ wholly transparent) through adopting several direct (e.g. quality management) and indirect (e.g. value engineering and value management) controlling measures. In addition, the contractual safeguards and other ‘soft’ relational reinforcements (e.g. Partnering) have been widely adopted as supplemental shields against several problems (i.e. with respect to performance and productivity aspects) originating from unnecessary rework and wastages in construction projects.

The Hong Kong based Construction Industry Review Committee (i.e. CIRC, 2001) emphasized on the increasing need for improving the performance in the construction industry by reducing non-valuing adding transactions (such as rework and wastages). Thus, the ongoing pilot research aimed for some preliminary targets of mapping rework and the resultant findings (e.g. through interviews and questionnaire survey) as well as the results of prototype modelling (e.g. using artificial neural networks) are encouraging. The ongoing pilot research could be deemed as a part of a wider international rework study initiatives that target to develop a staged life-cycle framework which would be ultimately useful to (a) reduce the incidence and costs of

rework in construction projects and (b) minimise corresponding losses incurred by project participants and other stakeholders. Other countries currently involved with such extensive rework studies are Australia, Canada, Sweden, UK, and USA. The intensity of worldwide research efforts and the significance of the rework problems identified in the Hong Kong based study mainly indicated that a focused large scale study is essential (and timely) to (a) map the rework occurrences and their root causes and (b) closely study the corresponding impacts and resultant ripple effects. A set of longitudinal and cross-sectional observations (e.g. through case-studies) are planned in that large scale focused study. Furthermore, developing of reusable knowledge-bases, useful tracking models and benchmarking frameworks are targeted through seeking for academia-industry collaboration and cooperation.

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