

A Guide to Construction Rework Reduction



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A Guide to Construction Rework Reduction

Construction Productivity Research Program

Construction Industry Institute

Implementation Resource 252-2b

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Executive Summary

In an ideal project environment, the implementation of a best practice like quality management would result in zero rework. Yet experienced project personnel understand that certain forces remain outside of their control. Indeed, on a typical project, rework costs between two percent and 20 percent of a project's contract amount. Reducing rework improves project performance, and reducing rework labor hours translates directly into improved labor productivity. In 2003, CII launched Research Team (RT) 203 as part of its effort to reduce construction rework. The team identified and described the major factors related to rework potential, and formulated a self-assessment opportunity checklist to strengthen corporate construction quality processes to reduce field rework.

In spite of this practical approach to reducing rework, efforts to reduce rework are still often impeded by a perception that rework is beyond the control of the contractor, or by a failure to implement a rework reduction program (RRP). When an RRP is deployed on a project, workers often perceive disincentives to report rework. RT 252 formulated the following guidance for addressing these issues:

- an explanation of how to deploy an RRP
- a top-ten list of rework reduction ideas
- innovative approaches to incentivizing rework reporting.

This guidance can be adapted to any construction project.

An RRP is first and foremost a measurement system for monitoring the magnitude and impacts of field rework. Only when organizations begin to measure—and thus really understand—the impact of rework on their projects, do they fully appreciate the economic benefits and productivity improvements that reducing rework makes possible. An RRP operates by managing a continuous improvement loop with four processes:

1. rework tracking and cause classification
2. evaluation of rework and its causes
3. corrective action planning
4. integration of changes into the total management system.

An RRP program implements specific remediation tasks to reduce rework, and is a long-term approach to reducing it on all ongoing projects of the company.

To validate these RRP guidelines and processes, RT 252 investigated an RRP already being implemented in the field along these guidelines. The team analyzed thousands of project records over a three-year time period to isolate impact trends on rework in terms of frequency, cost, and labor hours. The results indicate that a properly designed and implemented RRP can significantly reduce rework.

The overall mission of RT 252's six-year research program is to improve construction productivity. To achieve this mission, the team measures three aspects of productivity: 1) labor productivity (hours/unit), 2) direct work rate, and 3) rework rate. The team has pursued four research thrusts in its development of CII products to improve project productivity in terms of these measures:

- developing a best productivity practices implementation index and guide to productivity improvement
- identifying high-impact productivity innovations
- using the CII BM&M database to uncover new relationships between CII practices and productivity
- developing tools such as “activity analysis” that can be used to improve direct work rate.

This RRP guide is a product of the innovation thrust. Its place in the larger productivity research program, as described above, is also illustrated conceptually in Figure 1 below. It is mapped out in more detail in Research Summary 252-1b, *Construction Productivity Research Program – Phase III*.

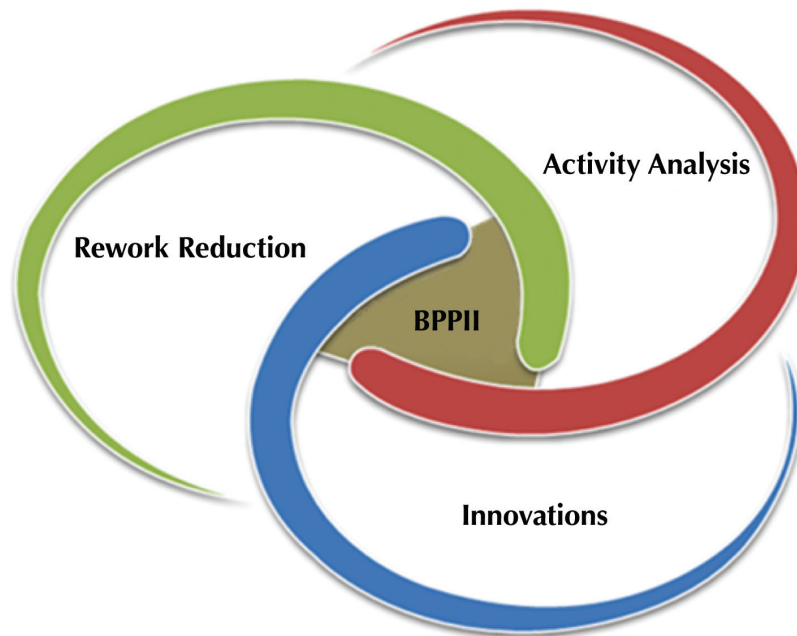


Figure 1. Construction Productivity Research Program strategy

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Chapter 1:

Introduction

Measure twice; cut once.

– Anonymous

1.1 Field Rework and Rework Indices

In a perfect world, preventing rework would be as simple as following the advice quoted above, and in the real world, implementing quality management practices and other CII Best Practices will mitigate most rework. But when dimensions are missing from drawings, processes are imperfect, and human error occurs, rework is difficult to prevent.

Construction field rework means that an action must be executed more than once in order to achieve the specified objectives. This causes the unnecessary consumption of additional resources—i.e., labor, materials, and facilities—beyond what would have been required had the action had been performed only once. In construction activities, in addition to cost and schedule overruns, rework has the further effect of causing potential risk with respect to quality and safety. Many existing studies have quantified the impact of rework on a project primarily in terms of cost, focusing mainly on classifying and measuring the causes of rework.

Several definitions of rework have been formulated, all differing in terms of verbal description, scope, and measurement. This guide uses the following CII definition:

Activities in the field that have to be done more than once, or activities that remove work previously installed as part of a project.

It is important to note that contractual order changes, scope changes, design changes or errors, and offsite fabrication errors that do not affect field construction activities (i.e., that do not require onsite rework) are not considered field rework. The most direct metric for the impact of rework is its cost. Researchers who have studied the rework issue in construction have almost always investigated the cost of rework as a percentage of the actual value of the contract. Many CII members also use this metric.

One research effort conducted case studies of rework costs for a residential project and an industrial building project, and found that the direct cost of rework was about 3.15 percent and 2.40 percent of the value of the entire contract, respectively. The study also determined that the cost of rework on civil and heavy industrial engineering projects could be significantly higher, averaging up to 12.4 percent of the value of the contract.

Previous CII research has obtained similar data for the cost of rework. Surveys conducted by CII Research Team 203 showed that the overall range of field rework ranged from 0.5 percent to 19 percent, with an average rate of 3.13 percent. The surveys collected significant amounts of data from

22 greenfield or modification and maintenance projects. These figures illustrate the fact that additional costs due to rework have a considerable adverse impact on project performance. In addition to the impact of cost on performance, the additional time required to re-do the work also results in a time shift or delay that is likely to affect the project schedule.

In Chapter 4 of this guide, the following three additional rework indices are used for evaluating the construction performance improvement achieved by reducing field rework. Note that the total rework cost includes the costs to dismantle and rebuild.

1. Rework frequency

Occurrences of rework in units of time duration

2. Rework cost rate

$$\text{Rework Cost Rate} = \frac{\text{Total Rework Cost for a Work Package}}{\text{Total Field Construction Earned Value for a Work Package}}$$

3. Rework labor rate

$$\text{Rework Labor Rate} = \frac{\text{Total Rework Labor Hours for a Work Package}}{\text{Total Field Construction Earned Value for a Work Package}}$$

Work package is defined as a scope of work for which all resources are accounted.

1.2 Rework Reduction Programs

Reducing field rework is widely regarded as an effective way of improving construction performance in terms of productivity, cost, schedule, quality, and safety. While much research and many existing rework reduction programs address this challenge, RT 252 identified a need for further analysis and continuous improvement of rework reduction methods. The research team developed a generalized conceptual model for a rework reduction program, aimed at reducing rework by managing a continuous improvement loop with four functional processes:

1. rework tracking and cause classification
2. evaluation of rework and its causes
3. corrective action planning
4. integration of changes into the total management system.

Each CII member organization will have to customize this program to some extent to fit its own operational environment. RT 252 conducted case studies to examine and verify the functional

Each CII member organization will have to customize this program to some extent to fit its own operational environment. RT 252 conducted case studies to examine and verify the functional mechanisms and effectiveness of this generalized RRP. The team focused on a representative rework reduction program implemented in a small project environment, and analyzed the achieved impact trends on rework in terms of frequency, cost, and labor hours. The results indicate that rework can be reduced significantly with such a program.

The RT 252 Rework Reduction Program is designed as a secondary supportive management tool in a company's management strategy toolbox. The program implements the appropriate remediation tasks to reduce rework in construction performance. It is a long-term program that takes all of a company's ongoing projects into account.

To be able to control all the management practices related to the root causes of rework, project owners or general contractors who undertake Design-Build or EPC contracts should lead the projects' RRP. (See Section 3.3 below for a detailed discuss of root causes of rework.) Even though design and engineering issues are not under the control of most construction contractors or subcontractors, RRP can still facilitate the improvement of most construction management practices to reduce rework. Furthermore, for the purpose of continuous improvement, an RRP should be conducted at the company portfolio level. This is because the accumulation and long-term analysis of data on the causes of rework causes provide valuable lessons for future projects.

The purpose of the RT 252 Rework Reduction Program is to track construction rework, to decrease the occurrence of rework and its adverse impact on project performance, and to improve productivity. It may also provide the following potential benefits:

1. improved quality of work from increased awareness of root cause issues and implementation of corrective actions
2. opportunities to share the lessons learned through communications with other sites
3. decreased production pressure when critical path work is done right the first time
4. opportunities to compare company performance against industry standards.

Chapter 2:

A Model Rework Reduction Program

This chapter presents a model rework reduction program (RRP); its purposes are to track construction rework, to decrease its occurrence and adverse impact on project performance, and to improve productivity. The following functions are specified:

- Identify the construction field rework.
- Determine and classify the root causes of the rework.
- Document the rework events and deliver the rework lessons to the relevant group.
- Quantify the impact of the rework on project performance.
- Develop a corrective action plan to eliminate the root causes.
- Plan an updated improvement scenario for changes to the project management system.
- Implement the corrective action plan.
- Verify the effectiveness of the actions with respect to eliminating the causes.

The model RRP includes the following processes:

1. **Rework tracking and cause classification** – detecting and identifying the rework that occurs in the defined work scope and identifying the causes of the rework.
2. **Impact evaluation and trend analysis** – compiling data and quantifying the impact of the rework on project performance in terms of cost, schedule, and quality; identifying trends in the impact over time as well as the causes.
3. **Corrective action planning** – developing options and actions that will bring about changes in the project management system, with the goal of reducing construction rework.
4. **Intervention and integration with the project management system** – integrating the input, output, and functions of the model RRP into the project monitoring and control process; using the information system as the platform for the integration.

Figure 2 presents a flow chart of these processes.

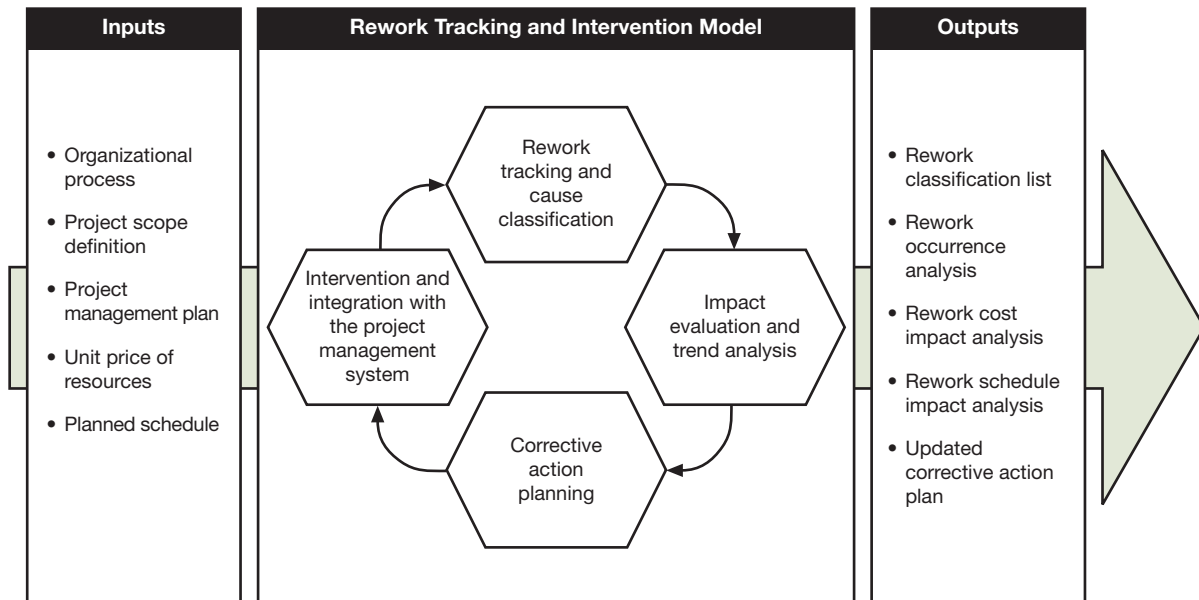


Figure 2. Process flow chart of model RRP

The model rework reduction program has the following features:

1. **Open circulation** – The rework tracking and intervention process is a four part cycle. (See Figure 2.) Output from one part of the cycle is the prerequisite for the next part. Each corrective action plan produces changes and improvements to the management system for each iteration of this continuously repeating cycle.
2. **Results-oriented** – The RRP’s demonstration of the impact of rework on project performance—in terms of classification of causes, quantitative analysis, and monetary evaluation—indicates how and how much rework wastes time and money. The program’s demonstration can identify efficient actions that could be taken to control rework, from alerting management staff to remedying the rework. The analysis and demonstration of the impact of rework can efficiently guide corrective action planning.
3. **Self-learning** – The RRP process is reiterative over the duration of individual project performance timelines, and also applies to a program of small projects. This wider application facilitates the ability of the management system to learn to recognize and control rework.

2.1 Rework Tracking and Cause Classification

Rework tracking and cause classification determine which activities constitute rework and which conditions cause the rework. The rework events should be documented, and the records should include the time, duration, participants, labor hours, schedule shift, materials, equipment, and characteristics of the cause. The process should be initiated by the workforce supervisor, and the program participants can include the site manager, the site management team, the project manager, and consultant engineer. All project personnel should be encouraged to record rework events. A sample rework record form is included in Appendix A, and sample processes for implementing the model RRP are included in Chapter 3.

The following components are included in the “inputs” box presented in Figure 3:

1. **Organizational process assets** – Information from previous projects from rework tracking and classification, including actual data and lessons learned, may be available for the present project. The experience derived from RRP on previous projects can enhance the ability of both experienced and inexperienced personnel to recognize and analyze the causes of rework.
2. **Work breakdown structure (WBS)** – The WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables. The WBS organizes and defines the total scope of the project. The planned work contained within the lowest-level WBS components—organized as it is into work packages—can be scheduled, cost-estimated, monitored, and controlled. The information for work packages is the essential background information for identifying rework and its causes.
3. **Rework classification structure** – The rework classification structure provides a framework for tracking and classifying the rework. It should be customized for project classes, addressing particular organizational characteristics and specific contractual conditions and construction requirements.

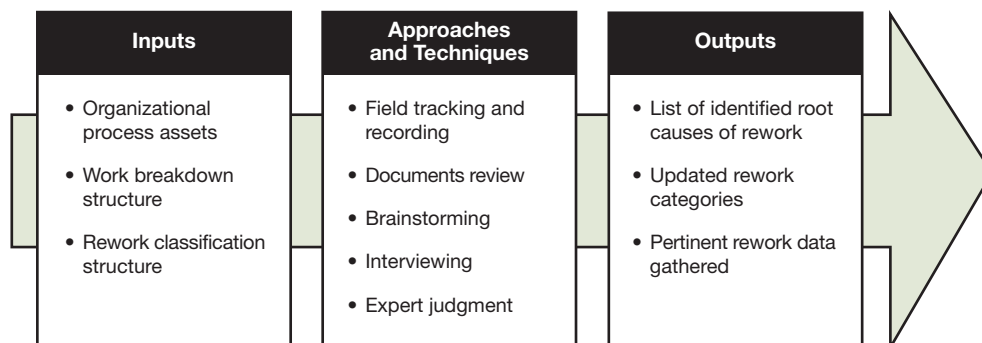


Figure 3. Rework tracking and cause classification

2.1.1 Rework tracking and cause classification: approaches and techniques

The following components are included in the “approaches and techniques” box presented in Figure 3:

1. **Field tracking and recording** – Site staff, including foremen, site engineers, and the site supervisor, recognize rework on the basis of their experience and the lessons they have learned. They are encouraged to make an initial identification of the root causes of any rework and to note all pertinent information.
2. **Documentary review** – Documentary review facilitates the learning of lessons from the rework events that occur in the current project or that have occurred on a previous project. Such review enhances the ability of project personnel to recognize rework and its causes. It also serves as a warning so that staff can prevent similar rework.
3. **Brainstorming** – The goal of brainstorming is to obtain a comprehensive list of possible root causes of the rework. The project team typically performs brainstorming to correct any errors in the initial classification of the causes of the rework. This part of the process can identify a biased judgment from any single member of the project team. Categories of rework causes, such as the ones included in the cause-classification structures mentioned above, can be used as a framework for brainstorming.
4. **Interviewing** – Interviewing experienced project participants and experts in specific areas can help identify rework and its causes. Interviews are one of the main sources of information for gathering pertinent rework data.
5. **Expert judgment** – Expert judgment, the informed opinions solicited from individuals with particular expertise, should be used to obtain a rapid assessment of a particular aspect of nonconformance. Such valuable judgment is integral to most other decision making tools for identifying the root cause.

2.1.2 Rework tracking and causes classification: outputs

The following components are included in the “outputs” box presented in Figure 3:

1. **List of identified root causes of rework** – The rework events identified, including their root causes and any uncertain project assumptions, should be listed. Rework events can have more than one root cause.
2. **Updated rework categories** – The process of tracking rework can lead to the addition of a new category of rework causes.
3. **Pertinent rework data gathered** – Pertinent data includes the frequency of the occurrence of rework events, direct labor hours, direct costs, and any schedule delays caused by the rework.