NAC Executive Insights

Rework in Engineering and Construction Projects

Key Points

- Rework factors are categorized into four broad categories: project, human, organizational, and complexity.
- Rework impacts cost, schedule, and, importantly, morale and trust.
- Strategies exist to reduce the potential for required rework. Forty-eight control points are suggested.

Introduction

The impacts of design and construction rework have been well researched and documented over the years. Despite this, rework remains a systemic industry challenge and contributes to cost overruns. This Executive Insight looks at some factors that lead to rework and their impacts. Importantly, a range of rework control strategies and tactics are suggested.

Factors That Lead To Rework

Factors that lead to rework can be categorized in various ways. One method is to divide them into four categories:

- **Project** – modified (including changed requirements, codes, standards), incomplete, or unclear scope[1] (changes); incomplete, unclear, or poor-quality design and design documents (RFIs); site and location issues (improper survey/layout; geotechnical or other underground factors; unrecognized environmental factors).
- **Human** – Incomplete or lack of appropriate knowledge or skills (experience), including poor workmanship; lack of diversity of thinking; effectiveness of reviews.
- **Organizational** – communication deficiencies; inadequate management and coordination, including reviews; poor supervision; weak quality systems (including quality oversight of subcontractors) and cultures; unrecognized coupling of activities and constraints; poor safety culture and commitment.
- **Complexity** – technical, human, execution, and informational complexity; unagreed to or emergent objectives.

[1] Executive Insight Know What You Are Trying to Accomplish: The Primacy of the Scope Baseline; https://www.naocon.org/wp-content/uploads/Know-What-You-Are-Trying-to-Accomplish-The-Primacy-of-the-Scope-Baseline.pdf

Impacts of Rework

The impacts of rework on project performance are expansive and detrimental. Impacts on cost and time are to be expected, but human impacts cannot be ignored. Select impacts include:

- Delay
- Productivity loss with attendant effects on cost and schedule
- Labor force availability, especially when skilled trades are involved
- Increased material and wastage costs
- Workforce morale and psychology
- Stakeholder conflict and trust (owner, contractor, engineer, other third party stakeholders)

Examples of Rework Challenges and How They May Be Addressed		
	Challenge	**Remedy**
Scaffolding	Modifications and relocation/ reconfiguration required due to failure to recognize future needs, obstructions, and complications	Scaffolding and other temporary works reflected in 3D/4D models, allowing evolving conditions to be assessed as construction progresses
High Density Polyethylene (HDPE) Piping	Material and weld testing inconsistent, often requiring replacement and rework in field	Develop and gain approval of new international testing standards

Control of Rework

This Executive Insight is primarily focused on identifying ways to control rework in engineering and construction projects. Control strategies and tactics are available throughout the project execution lifecycle. Forty-eight recommended control points have been divided into five groups. The five groups address: project foundations, project flows, stakeholder engagement, technical robustness, and project execution readiness. The identified strategies for each are presented below:

A. Strengthened Project Foundations

1. Scope completeness reviews, including using emerging artificial intelligence (AI) tools (preventive)
2. Scope change control (corrective) – reconfirmation of project objectives; root cause analysis (assure full impact and cause of change understood); modifications to project plan, budget, and schedule detailed; configuration management verified; impact on project risks assessed; formal approval of change (include determination of need for change); update baselines and project management plan (ask: when is the change most efficiently made?)
3. Adequate site investigations
4. Early value management studies and workshops (act to limit client-directed changes)
5. Ensure plot plan and layout allow for late delivery of major equipment
6. Owner understanding of its role (governance vs micro-management)

7. Robust project baselines

Project baselines are comprised of:

- Prime contract
- Project scope
- Project execution plan, including change management approach
- Project estimate
- Total project schedule with key milestones
- Project risk assessment

B. Increased Focus on Project Flows

1. Comprehensive design planning that reflects procurement and construction requirements
2. Adequate design staffing and design timeframes
3. Comprehensive design procedures that are being utilized
4. Smooth flow of design information from suppliers
5. Agreed-to design freeze
6. Strong, rigorously implemented quality system, including effective, timely reviews and strong quality audit system
7. Up-to-date documents/BIMs (version control is essential)
8. Complete tender packages and contract documentation
9. Effective workface planning and scheduling of required resources
10. Lessons observed translated into lessons learned by communicating broadly in a timely manner

C. Strengthened Stakeholder Engagement

1. Early contractor and other key stakeholder engagement (expanded basis of design)
2. Early Operations & Management involvement to reduce rework during startup and commissioning phase

D. Technical Robustness

1. Utilize AI based design checking tools
2. Confirm adequate support, flexibility, and expansion provisions for piping systems
3. Check equipment flange bolt holes for correct orientation/straddle of centerline; check equipment at suppliers before shipment
4. Reduce number of field welds required
5. Establish a Zero Rework culture and target; track, report (100 percent reporting without fear of retribution[2]) and benchmark rework; identify rework risk areas along critical path
6. Minimization and timely resolution of Requests for Information (RFIs)
7. Early RFI trends monitored to identify potential areas of design challenges
8. Strong, systematic documentation to support change requests and resolve latent issues (avoidance of similarly caused rework)
9. Effective use of BIM to identify potential conflicts, challenges, and incomplete design or vendor changes
10. Appropriate but only necessary notes on drawings for intended purpose
11. Strong interface management and configuration control processes

[2] A culture of reporting all rework events similar to the culture of reporting all safety incidences is required.

12. Supplier-to-supplier connections must be carefully checked for compatibility (example: buss duct to switch gear)
13. Safety through design practices employed (hazard avoidance)

E. Construction Execution Readiness

1. Workforce, subcontractor[3], and supplier quality and availability
2. Effective use of information technology
3. Rigorous material quality testing
4. Shop inspection of all specialized equipment prior to shipment to the field
5. Real-time inspection of the works (task-completion focused)
6. Prudent use of hold and control points
7. Periodic 3D scanning of installed works as part of progress monitoring and configuration control
8. Effective materials management to ensure correct materials and equipment are used; minimize relocations of materials at site to reduce damage
9. Improved access to real-time information utilizing wearable technologies
10. Effective visibility in multi-layered subcontracting
11. Supply chain quality visibility and inspection rights
12. Pre-shipment inspection of prefabricated items
13. Use of appropriate construction means and methods and fit-for-purpose processes and tools
14. Adequate protection of completed works; sequence of construction to consider potential damage to completed works
15. Track and assess rework items and ripple effects using an established taxonomy
16. Incentivize/disincentivize rework

Summary

Rework control really begins at the point of project conception. Engineering and construction rework, however, remains a challenge. Strategies to improve outcomes exist, and many have been identified in this Executive Insight. Newer technologies (BIM, AI, laser scanning) provide new tools to improve performance throughout the project execution lifecycle.

[3] A strong pre-qualification process is helpful here with focus on experience, backlog, key personnel, organization size, and resource availability. All need to be discussed at contractor and subcontractor selection time. Subs, CMs, and GCs all need to be transparent.

About the Author

Bob Prieto was elected to the National Academy of Construction in 2011. He is a senior executive who is effective in shaping and executing business strategy and a recognized leader within the infrastructure, engineering, and construction industries.