



Construction Industry Institute®

The Impact of Changes on Construction Cost and Schedule

The purpose of this publication is to make available to industry the results of research conducted by the Construction Industry Institute (CII). The publication does not necessarily represent the views of all CII member companies, but is offered as a contribution to the industry.

CII was founded in 1983 to improve the cost effectiveness of the nation's largest industry. The members, who represent a broad cross-section of owners and contractors, believe that many of the problems that limit cost effectiveness are common ones, and that real improvements can be best accomplished in a cooperative environment with the benefits being shared by the construction industry at large.

Construction Industry Institute®
The University of Texas at Austin
3925 W. Braker Lane (R4500)
Austin, Texas 78759-5316
(512) 232-3000
FAX (512) 499-8101

Not printed with state funds

The Impact of Changes on Construction Cost and Schedule

**Prepared by
Construction Industry Institute
Cost/Schedule Controls Task Force**

**Research Summary 6-10
April 1990**

© 1990 Construction Industry Institute™.

The University of Texas at Austin.

CII members may reproduce and distribute this work internally in any medium at no cost to internal recipients. CII members are permitted to revise and adapt this work for the internal use provided an informational copy is furnished to CII.

Available to non-members by purchase; however, no copies may be made or distributed and no modifications made without prior written permission from CII. Contact CII at <http://construction-institute.org/catalog.htm> to purchase copies. Volume discounts may be available.

All CII members, current students, and faculty at a college or university are eligible to purchase CII products at member prices. Faculty and students at a college or university may reproduce and distribute this work without modification for educational use.

Printed in the United States of America.

TABLE OF CONTENTS

<i>Chapter</i>	<i>Page</i>
1. Introduction	1
2. The Anatomy of Changes	3
Contract Changes Clause	3
Types of Changes	3
Sources of Changes	4
Timing of Changes	5
Traditional Methods for Costing Changes	5
Direct and Consequential Effects of Changes	5
Disclaimers by Clients and Engineers	6
3. The Direct Impacts of Changes on Cost	7
Productivity Degradation Due to Interruptions	7
Productivity Degradation Due to Sustained Overtime	10
Delays	10
Equipment and Labor Spent in Removing Existing Work	11
Materials Wasted by Removal of Existing Work	11
Nonproductive Periods during Redirection of Work	11
Recovery Scheduling	11
4. The Direct Impacts of Changes on Schedule	12
Direct Effect Evaluation	13
5. The Consequential Impacts of Changes	15
Consequential Effects	15
Evaluation Tools	16
Evaluating Schedule Changes	17
Evaluating Consequential Costs	17
6. Summary	19
Recommendations and Ideas to Consider	19
References	22

INTRODUCTION

Two things can be said about almost any engineering and construction project: (1) there will be changes made during the course of construction, and (2) the owner and the constructor will seldom initially agree on the total effect those changes have on the cost and schedule of the project.

Large-scale construction is complex enough without changes. It requires detailed planning to integrate multiple crafts, subcontractors, and vendors working with a wide variety of materials and operating under a full range of weather conditions. Changes, in most cases, are disturbances that interfere with the planned, orderly progression of work. The question becomes: What are the true consequences of these disturbances?

Numerous studies of craft worker productivity have been conducted in recent years. The term demotivator has come out of these studies. It is a term applied to any condition that contributes to lower craft worker morale and, as a consequence, to lower productivity. Changes are always listed as a major demotivator. When a crew that has developed momentum in accomplishing a given task is then told to stop and change what they are doing, they will be demoralized and slow in recovering momentum. Then, if some work must be removed as part of the change, materials are wasted plus worker and equipment hours are expended in the demolition operation. The potential effects encompass lower productivity, additional worker-hours, increased costs, and increased time.

Is the impact of a change, however, confined to the crew involved in the changed work? A critical path schedule for the typical large project shows that many tasks occur in parallel and have complicated dependency relationships. Only a small percentage of tasks can be accomplished in isolation of the others. Thus, logic dictates that any change to one activity can easily have a ripple effect on others.

A change also involves the overhead staff. Significant added administrative and engineering effort is required to evaluate, process, and manage each change. Any changes that extend total project time also will extend the length of time that overhead personnel must be on the job and supporting facilities functioning.

This publication examines the subject of changes, identifies potential impacts on project costs and schedule, and provides guidance for evaluating those impacts. It is based in part on CII-supported research performed by the University of California-Berkeley. That research has resulted in the publishing of the CII source document, *Changes and Change Orders: Their Magnitude and Impact*, which details results of a literature search and field studies of

three projects. The report is available from CII and readers are encouraged to purchase it for more detailed study of this subject.

While this publication generally will discuss changes as given to a general contractor by an owner or an owner's agent, the principles are equally applicable to changes given by a contractor to a subcontractor.

Readers are encouraged to study the CII publications listed in the References, which provide definitions of terms and more detailed discussion of various topics mentioned in this publication.

THE ANATOMY OF CHANGES

For the purposes of this publication, a change is any modification to the contractual guidance provided to the constructor by the owner, owner's agent, or design engineer. Thus, it encompasses changes in specifications, drawings, and other written or oral guidance.

Initial guidance comes to the contractor in the form of a contract package. This package is the basis for the contractor's bid or proposal. The contractor will have developed project schedules, budgets, and a variety of detailed implementation plans using this guidance. Obviously, any change to the original guidance can be expected to alter the contractor's plans.

Changes will affect contractor planning on both cost-reimbursable and fixed-price projects, but the consequences of these changes, from the contractor's viewpoint, are quite different. On the reimbursable project, there is a direct pass-through of costs and schedule consequences to the owner. On a fixed-price contract, the contractor usually is in the position of identifying and justifying all cost and schedule effects as a basis for contract price and schedule adjustments.

Contract Changes Clause

The construction contract for a fixed-price project should contain a Changes Clause. This clause establishes the owner's right to make changes, and should provide a mechanism for their administration and resolution. In a CII study of problem construction contract clauses, however, the Changes Clause is identified as among the most troublesome:

"Problems most often encountered with construction change clauses involved definition and negotiation of costs, dispute resolution, and time required for approvals. A lack of well-defined procedures often compounded the problem." (Reference 2)

Types of Changes

Changes can involve addition of work (additive changes), deletion of work (deductive changes), demolition and rework, specification change, or some combination of these. There also are changes which do not involve quantities of work, but which effectively alter contract costs and/or schedules—a delay in delivery of owner-furnished materials is an example. A *force majeure* event can have the effect of a change in that both costs and time can be affected; however, a *force majeure* event differs from a change in that it may entitle a contractor to only time adjustments, not cost, on a fixed-price contract.

Changes also may be classified as formal, constructive, and cardinal. A *formal change* is one introduced by the owner or owner's agent under the mechanism of the contract's Changes Clause. A *constructive change* results from an action by an owner or owner's agent that has the effect of directing a change but is not initially documented as such. A *cardinal change* is a change outside the scope of the current contract and should be executed only after complete renegotiation of the contract.

Sources of Changes

Changes may originate with the owner, owner's agent, design engineer, or contractor. Owner changes may be occasioned by a change in scope of the project (research has shown this to be the major source), a change in some functional or maintenance requirement within the current project scope which requires a design change, a change in need dates, problems with owner-furnished materials, or a user desire. Design personnel are the agents for implementing most owner-originated changes, and are the originators of changes caused by inadequate knowledge of existing conditions at project sites, design errors, unforeseen conditions, new regulatory requirements, or revised design parameters as might occur on a project where construction is initiated before design is complete. If the owner employs a separate project manager to provide overall project management, that agent can introduce changes, particularly schedule changes, in fulfilling management duties to coordinate all project activity. That individual also may be responsible for constructive changes that arise from unwarranted interpretation of specifications or personal desires. The contractor also may be a source of changes if design errors are found or if, as a consequence of a value engineering clause in the contract, the contractor suggests a more cost-effective design that is subsequently adopted. Also there may be any number of minor field-originated changes such as valve relocation to avoid interference, and other comparable problems that are best solved without recourse to formal change procedures.

With advances being made in computerized design, the changing of designs has become a quick and simple process, requiring only a few clicks of the computer mouse or the tapping of a wand. Contrast this with the days of hand-produced drawings when a change required many design and drafting hours. This ease of change reduces the reluctance to make changes and carries with it the potential for more frequent change, some of those changes being optional. While computerized design should reduce human errors associated with calculations and interferences, it will not eliminate those frequent design-engineer errors associated with inadequate knowledge of existing site conditions, methods of construction, materials of construction, and procurement lead times. Nor will it eliminate those changes associated with scope change. Thus, at this point, conclusive statements cannot be made concerning the potential for modern design methods to reduce the change problem.