CONSTRUCTION COST ESTIMATING FOR PROJECT CONTROL

BY
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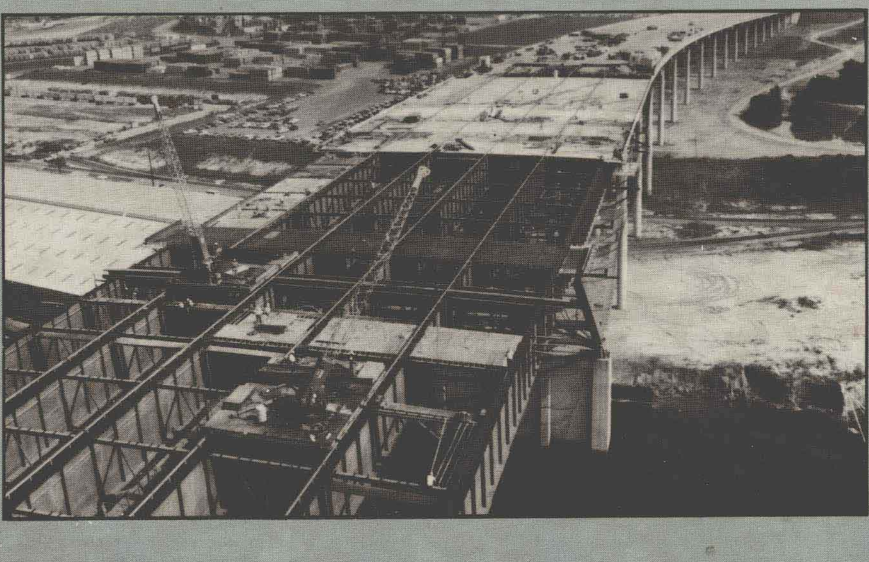

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Library of Congress Cataloging in Publication Data

Neil, James M.
Construction cost estimating for project control.

Includes index.
1. Building—Estimates. 2. Construction industry—Management. I. Title.
TH435.N34 624.1'068'1 81-5211
ISBN 0-13-168757-3 AACR2

Editorial/production supervision and
interior design by Karen Skrable
Manufacturing buyer: Joyce Levatino
Cover design by Diane Saxe

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

Prentice-Hall International, Inc., *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall of Canada, Ltd., *Toronto*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Prentice-Hall of Southeast Asia Pte. Ltd., *Singapore*
Whitehall Books Limited, *Wellington, New Zealand*

PREFACE

Dun & Bradstreet reported the business failure of 154 construction contractors in November of 1976, up 12% from the year before. During the first 11 months of 1976 a total of 2280 contractors experienced business failure, up 7% from the previous period. Certainly, the recession of the prior 2 years was a factor since the construction industry was one of the heaviest hit and the slowest to begin recovery. In fact, one out of every five business failures in the mid-1970s was a construction contractor. In some areas 20 out of every 100 contractors went bankrupt, a rate much higher than that experienced in periods of normal construction activity when one out of 100 is the failure rate. But, even in the difficult mid-1970s, more contractors remained in business than dropped out which would indicate that there is a way to be successful as a contractor in both good and bad years. Why are these contractors still in business? What is it that they do which sets them apart from those that fail? While this text does not propose to provide the complete answer to either of these questions it does pursue the theory that most contractor failures can be traced to faulty cost engineering.

Cost engineering is a relatively new term in the world of the contractor. Few engineers would think of it as a function for which they might be responsible. What then is cost engineering? The American Association of Cost Engineers defines it as

Cost Engineering: *That area of engineering practice where engineering judgement and experience are utilized in the application of scientific principles and techniques to problems of cost estimation, cost control, business planning, and management science.*

In light of this definition, it is obvious that cost engineering must be understood and practiced by every contractor since cost engineering is concerned with everything that affects the ultimate goal of every businessman—the making of a reasonable profit. For a contractor to go bankrupt there must be a failure in the cost engineering area. It could be faulty cost estimation, sloppy cost control, poor business planning, unprofessional management, or a combination of these.

This text has been written to provide a basic introduction to cost engineering of construction through detailed presentation of cost estimation and its relationship to the other project control functions of scheduling, budgeting, and cost control. This book is designed for use as a text for a college or university course or for use in an in-house training program for industry personnel who are first undertaking job responsibilities in the construction project control area.

While the book concentrates on cost estimating, its approach to the subject gives considerable coverage to the contracting function, organization for construction, the total cost-engineering process for construction, and methods of construction. It is designed for education of both design and construction engineers and targets on the following objectives

1. To identify and examine the many components of construction cost and their variability.
2. To present a system for estimate development for major construction.
3. To emphasize that cost estimation is not an isolated function whose end is the preparation of a bid. Estimating must be organized to support and facilitate the entire project control process.

CONTENTS

1 ESTIMATING CASE STUDY: THE MONTREAL OLYMPICS COMPLEX

INTRODUCTION

Construction is inherently risky because a project must be priced before it is produced. Clients need prices during the planning and conceptual stages to permit development of budgets and financing plans. Then, as the designs are fleshed out, there is a need for updates on prices so that adjustments, if necessary, can be made to budgets or scope of work. Price is all important to a contractor bidding a fixed price contract; the organization must live or die with the bid price. Unfortunately, the accuracy record for estimating construction costs is poor; all too often key factors which affect cost are overlooked or undervalued. To emphasize and illustrate this, this text begins with a case study.

The subject of this study is the Olympics Complex in Montreal, Canada, built to accommodate the 1976 Summer Olympics. This complex is a classic among the many projects each year which drive clients and contractors into tears and bankruptcy because of cost overruns that develop between the budget phase and completion. Is the problem inflation? Certainly, inflation has an effect. Mostly, however, the problem is one of poor planning, design, estimating, and execution, each error contributing its share to the final financial nightmare. Hopefully, by reviewing this project and thoroughly studying following chapters you will become aware of those things that ultimately cost money to a contractor and client and will not similarly be caught short as a contractor or member of a contractor or client's staff when preparing a cost estimate.

BACKGROUND

On July 17, 1976, a young man and a young woman sprinted into the main stadium of the XXI Olympiad in Montreal carrying the traditional flaming torch. Of the millions who watched the event in person or on TV, few realized that these runners were entering a still incomplete stadium, a stadium that had been in planning since 1970. Until almost the last moment, the site had been the scene of frenzied activity as essential construction tasks were completed, temporary structures were erected to mask the incomplete portions, and all evidence of construction was evacuated from the area.

The main stadium was but one of many facilities that were part of the total. A velodrome for bicycle events, swimming pools, boat basins, an equestrian center, roads, walks, subways, practice fields, and many other structures plus landscaping comprised the total project. But the main stadium was by far the largest and most costly structure. Estimated by Montreal's mayor to cost $40 million in 1970, out of a total estimated complex cost of $120 million, the main stadium eventually cost in excess of $836 million and the total price exceeded $1.5 billion. What went wrong?

THE PROBLEMS

Design

The structures were ultramodern and dramatic in concept; they required new and complex construction techniques for the contractors who would execute the designs. The main stadium was designed to look from the top much like an elliptical seashell with a handle. The seashell portion has an elliptical opening in the center that, under the original design, could be open or covered with a retractable fabric cover controlled from a mast that partially overhangs the opening. As a cost-cutting measure, both the mast and the cover were eventually deleted. From the side, the plane of the opening at the top rises slightly from the mast (handle) end of the structure to the opposite end. (See Fig. 1-1)

The interior of the stadium was designed to provide pillar-free viewing by all spectators. To accomplish this, the main structural mem-

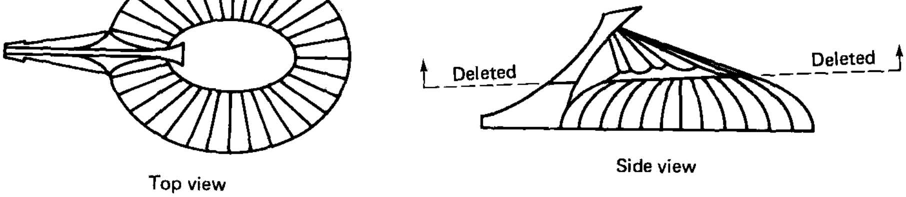

Fig. 1-1 Main Olympic Stadium.

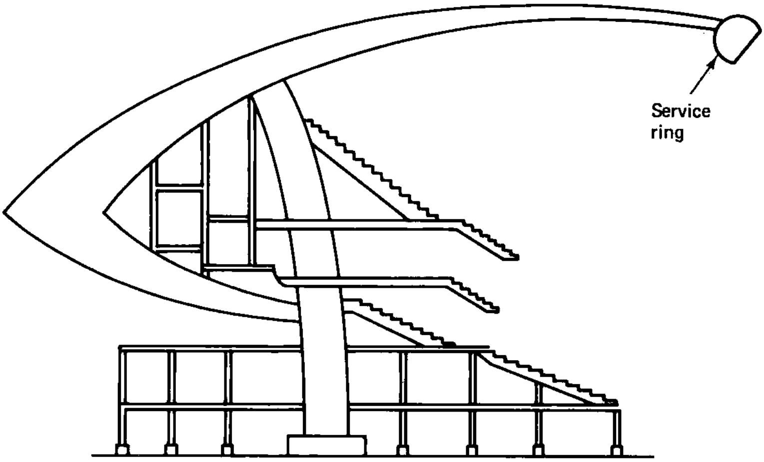

Fig. 1-2 Typical rib.

bers were designed as complex ribs as shown in Fig. 1-2. The ribs were assembled in the field by gluing the parts together with epoxy and posttensioning a number of precast concrete components. The ribs terminated at the top on a section of a hollow ring that forms the perimeter of the ellipitical opening. This ring houses lighting and other support systems. Because of the sloping top design of the stadium, the ribs were not of the same size. As might be expected, it was an impossible task to assemble and align them perfectly so misalignments approaching 6 in. were encountered. Such problems should have been expected and flexibility incorporated in the design. However, in this case, the design required almost exact alignment of adjoining ribs to permit the threading of posttensioning cable through tubes in the ring.

The posttensioned design feature added further headaches and costs during the winter months when water got into the many tubes and froze before cable had been threaded. Removal of the ice required expensive drilling and contributed further to the loss of time.

Still another problem attributable to a design that did not consider constructibility arose when it was determined that no scaffolding could be used inside the stadium to support the ribs and workers since scaffolding would unduly restrict access into the stadium area. The solution was to use many cranes, some to hold the ribs into position and others to hoist workers, tools, and materials to the overhead work positions.

Another example of cost increases attributable to complex design involved the viaduct on the main road passing the main stadium. The viaduct was on a straight section of roadway and could have been designed rather simply. However, the edge of the roadway was designed as a walk with a series of overhanging parapets with rounded exterior areas from which pedestrians could view the Olympic site. The support for the viaduct's main span looked much like the legs of an inverted swivel chair, being formed of four outreaching concrete legs each requiring numerous prestressing cables for strength. Formwork for some sections of the viaduct was reported to cost as much as $400 per square yard, about 15 times the cost of routine commercial formwork at the time. Overall, the viaduct, which could have cost as little as $5 million using a conventional design cost $14 million or $180 per square foot. Indicative of the complexity of the design was the fact that no contractor would take the project on a fixed price contract. The contractor who built it did so on a cost-plus-fixed-fee arrangement and then only with the condition that he was not responsible for the completed structure.

Labor

Labor was union. Approximately 80 days were lost to strikes and the equivalent of about another 20 days were lost through slowdowns. The project had all the qualities which tempt labor unions to take advantage of the client—there was a fixed deadline, labor was scarce, and there were no agreements between labor and management to restrict strikes or other union activity during the course of the project. There was some sabotage and it was eventually necessary for the client to use police to control labor entry into the site so that known troublemakers could be denied access. The situation was so bad that, in early 1976, the Province of Quebec issued an ultimatum to the workers telling them to either get on with the work or the project would be closed down and the Olympics moved to other facilities. It is interesting to note that production at the main stadium during March and April 1976, following the ultimatum, was twice that recorded during the previous 6 months. While better weather conditions and greater experience by the contractors contributed to a 500% improvement, the ultimatum has to be counted as significant. Not to be outdone, the plumbers and electricians went into a slowdown during the last weeks of the project forcing a delay in the turnover of the project to the Olympic Organizing Committee from June 6 to June 14.

New Construction Technique

The use of the epoxy-glued, posttensioned structural members noted earlier was completely new to North American contractors although the technique has been used successfully in Europe. With any new technique there is a learning process which can be slow, painful, and expensive and this proved to be the case in Montreal.

Resource Shortages

The heavy concentration of construction activity in the Montreal area in support of the Olympics construction literally exhausted all local sources of labor, materials, and equipment. Consequently, these had to be imported from other areas of Canada and the United States. When labor is in short supply and the client is operating under a union agreement, union card-carrying workers must be sought from other areas by the hiring halls since union training programs are so structured that they are not responsive to sudden demands for qualified craftsmen using local personnel. These outside workers (travelers) are not necessarily of high quality and can include troublemakers intentionally introduced into the project.

In the case of construction equipment and materials, those obtained from outside areas carried with them the premium cost of transportation to Montreal often plus a higher purchase or lease price because of the circumstances.

Weather

Many construction operations cannot be performed in the Montreal area during the colder months unless protective measures are employed. Such protective measures cost added dollars, yet are essential on a tight-deadline contract such as this. The cost of heating measures at Montreal was about $400,000 per day at their peak.

Scheduling

A critical path network was prepared for construction of major Olympic facilities. Unfortunately, it had the earmarks of a schedule prepared by theorists unfamiliar with the real world of construction. So many events were scheduled for simultaneous execution that it would have been physically impossible to accommodate all the work forces at once in the area. Consequently, the schedule was abandoned and everything became a daily crash action.

Fixed Deadline

Since missing the opening date for the Olympics could be a national embarrassment for Canada, this project had a very positive no-later-than deadline. Such a deadline is realistic only if the planning, design, and construction activities precede this date in a coordinated manner with plenty of lead time. In this case, it is estimated that the planning started about 2 years too late for routine planning, design, and construction to