Fast-tracking of construction projects: a case study

P. FAZIO, O. MOSELHI,[1] AND P. THÉBERGE[1]
Centre for Building Studies, Concordia University, Montréal, Que., Canada H3G 1M8
AND
S. REVAY
Revay and Associates Ltd., Montréal, Que., Canada H3Z 1P9

Received April 29, 1987
Revised manuscript accepted January 11, 1988

The growing use of professional construction management has been synonymous with the development of new project delivery systems such as the phased construction approach and the fast-tracking technique. This paper establishes the distinction between these two types of approach which have become increasingly popular for reducing project duration. The paper further illustrates, through a case study, the possible consequences of compressing and overlapping design activities in a fast-track program to expedite project delivery. A delay analysis shows the impact of this accelerated technique on construction activities. The far-reaching effect of mistakes during the early design/engineering phase in a fast-track program is usually underrated. Accelerating a project through fast-tracking is a major decision, and construction professionals often are not aware of its implications. Based on the case study examined in this paper and other fast-track constructions previously analyzed, trouble areas requiring special attention have been depicted and recommendations with regard to the effective use of this technique are presented. It has also been shown that if intensified effort on problem areas is lacking, such a popular accelerated technique could result in unexpected delays.

Key words: fast-tracking, phased construction, professional construction management, design management.

L'utilisation croissante de services professionnels de gestion de la construction a coincidé avec l'apparition de nouveaux systèmes de remise des ouvrages tels que la méthode de construction par phases et la technique de suivi rapide. Cet article établit une distinction entre ces deux types de méthode de réduction de la durée d'un projet de plus en plus populaires. Par le biais d'une étude de cas, l'article illustre les conséquences possibles du chevauchement et de la réduction de la durée de certaines activités de conception, dans le cadre d'un programme de suivi rapide visant à accélérer la remise des ouvrages. Une analyse de retard illustre l'effet de cette technique sur les acivités de construction. L'impact d'erreurs commises durant la phase initiale de conception et d'étude est habituellement sous-estimé dans un programme de suivi rapide. Accélérer un projet par le biais d'un suivi rapide est une importante décision, et les spécialistes de la construction ne connaissent pas toujours les implications. À la lumière de l'étude de cas présentée dans cet article et des autres constructions à suivi rapide analysées précédemment, les domaines névralgiques nécessitant une attention spéciale sont décrits et des recommandations concernant l'utilisation efficace de cette technique sont présentées. Il a également été démontré que si l'on ne déploit pas suffisamment d'efforts intensifs dans les domaines névralgiques, une telle technique populaire risque d'entraîner des retards imprévus.

Mots clés : suivi rapide, construction en phases, gestion professionnelle de la construction, gestion de la conception.

[Traduit par la revue]

Can. J. Civ. Eng. **15**, 493–499 (1988)

Introduction

Management of engineering and construction projects has unquestionably become more complex in recent years. Prior to the 1970's, construction projects were delivered through the traditional approach with an architect/engineer for design/inspection and a general contractor for construction, or through the design–built approach featuring an engineer/contractor involved in all phases of the project, from inception through design to construction. During the 1970's, technical complexities of projects, increased government regulations, spiralling inflation, and political pressures all have contributed to the increased cost of construction which resulted in a search for new and imaginative procedures to ensure faster and more economical project completions. With the traditional project delivery system failing to meet the present challenges, the owners found it necessary to become more involved in the administration and management of their projects.

In an effort to shorten project durations and help meet overall project objectives, phased construction and fast-tracking management techniques have been developed as part of the professional construction management (PCM) approach. The PCM unites a three-party team consisting of owner, designer, and construction manager in a nonadversary relationship, and it provides the owner with an opportunity to participate fully in the construction process.

Both phased construction and fast-tracking compress the project duration by overlapping work packages. This growth in phasing the design and construction has been synonymous with the growth of PCM organizations (Gray and Flanagan 1984). As soon as the design and construction stages are overlapped, a whole new series of interrelationships amongst designers, contractors, and owners are formed which must be managed very efficiently to achieve successful completion of construction projects. Today, with the uncertainty of inflation and interest costs, and with the competitive business world requiring owners to do their utmost to beat market competitors, these accelerated project delivery approaches are becoming attractive.

This paper establishes the differences between the fast-tracking technique and the phased construction approach. It further illustrates, through a project study, the impact of compressing and overlapping design activities in a fast-track

NOTE: Written discussion of this paper is welcomed and will be received by the Editor until December 31, 1988 (address inside front cover).

[1]Authors to whom correspondence should be directed.

program in order to expedite project delivery. An in-depth delay analysis is presented to show the impact of fast-track-related problems on the construction duration. Finally, based on the project study presented in this paper and in reference to other fast-track projects that experienced difficulties, recommendations are made for the effective utilization of this accelerated technique.

Fast-track versus phased construction

Both phased construction and fast-tracking concepts are being used interchangeably in the literature and by construction professionals. Admittedly both concepts shorten time through overlapapping of design and construction phases, but this similarity should not be misinterpreted.

Phased construction basically calls for overlapping of discrete work packages, by issuing them at different intervals throughout the construction period. Design packages for excavation, foundations, structural, mechanical, etc. are separately produced in sequence by the architect, with the earlier packages let for bids and work commenced thereon before the later packages are completed. The design of each of these work packages is substantially complete when they are awarded. In order to shorten the whole project duration, critical work packages are issued to contractors as they become ready for construction.

In an effort to further reduce construction duration the fast-track technique has emerged, where overlapping goes one step further. This is achieved by overlapping the design and construction phases within each individual package. Under this approach the owner's architect develops schematic drawings and preliminary specifications, which are immediately used to estimate the project budget and get construction started. Without a full set of detailed plans and specifications, prospective bidders who are getting a rough idea of the work are asked to formulate a contract price. As soon as the construction progress of preceding packages is sufficent, the next work package is awarded with its design being completed in parallel with construction.

Also using the approach of overlapping work packages, fast-tracking could be viewed as an "accelerated phased construction." The time normally required for the cumbersome reconciliation of all drawings and specifications is being traded for a "finish as you go along" approach. It is then the owner's responsibility to complete the drawings and specifications in a manner consistent with the initial documents used by the contractors to begin construction. The status of design development for an individual work package at the time of award is therefore a prime determinant in classifying projects as fast-tracked or merely phased construction.

Despite the similarities between the two approaches, the fast-track technique requires considerably more attention in order to achieve successful project completion. Ruby (1978) and Sidwell (1983) pointed out two major challenges in fast-track construction: coordinating the construction work and providing subcontractors with the information they need for bidding. Clearly defined independent work packages are certainly important for both phased construction and fast-tracking (Schich 1982), while the latter specifically stresses the need for a flexible design (Trombley 1985). The importance of effective management during the design phase is stressed in several papers (Ruby 1978; Schich 1982; White 1980) and will be reviewed briefly.

Fast-tracking conditions

As long as the uncertainty of inflation and high interest costs persists, schedule and cost benefits will continue to dictate the use of accelerated construction programs. In theory shortening the construction period should result in lower financing risk and reduction of indirect construction costs. Accordingly it would seem profitable to adopt the fast-tracking technique on a general basis. In fact, however, only certain construction projects are potential candidates to this management approach.

The traditional project delivery system is still being applied to a number of commercial and governmental projects. Other projects such as power plants, petro-chemical facilities, oil refineries, and industrial complexes that require extensive design and procurement periods are potential candidates for fast-track and phased construction. Commercial projects were their earlier start-up may decide the ultimate profitability of the enterprise are also potential candidates.

The following conditions or project characteristics encourage design and construction overlapping:

1. *Financial conditions*: Important cost reductions and higher overall project profitability can be achieved by shortening the project duration.

2. *Project complexity*: It is advantageous to award separate early contracts for portions of the work that are identified as potential constraints.

3. *Political conditions*: Political decisions and budgetary policies can fix the start and completion dates on construction facilities.

In practice, by attempting to maximize the benefits of a shorter project duration or in order to meet a fixed delivery date, a phased construction program often slips into the characteristics of a fast-track one. There is also an important condition which qualifies fast-tracking from the start of the project:

4. *Market conditions*: For industrial buildings there are distinct advantages to being in production while the competition is still designing or building.

All of the above conditions demand that the project proceeds at as fast a pace as possible and call for a dynamic teamwork under the PCM approach, uniting the owner, acrhitect/engineer (A/E), and the construction manager (CM), who could be a general contractor as well, early in the preconstruction stage of the project. Through this "team approach" a good harmony is created from design through completion, in which the CM exploits his management skills to a greater limit to intergrate and coordinate design and construction overlapping (Linthicum 1982).

Performance evaluation of fast-tracking

There are basically two methods of analysis available to evaluate the performance of the fast-track construction approach. The first consists of a comparison between scheduling activities of a fast-track project and those of a traditional case hypothetically derived from it. The second uses the actual fast-track project to carry out an in-depth analysis of the accelerations and delays by comparing the as-planned and as-built schedules.

A recent study utilizing the first approach (White 1980) is based on the "TREND" analysis technique presented in 1972 by Benningson. The "TREND" model draws upon three independent theories, namely: interdependence, uncertainty, and prestige with due assumptions to enable the derivation of the hypothetical traditional case. Typical assumptions required to derive the traditional case include no change in activity duration from the fast-track to the traditional approach, the same construction activity precedences, and the same level of uncertainty for activity duration.

As such, the approximation and (or) assumptions made at this early stage in deriving the hypothetical model would have a direct impact on the reliability of the end results drawn from the comparisons. This method, although theoretically appealing, could result in misleading analysis due to the inherent limitation of the method described above. Furthermore, the method completely disregards the increased complexity in coordination and scheduling encountered on fast-track jobs. In view of the pitfalls associated with the first method, the second approach has been considered herein.

In general, more insight information can be gained in comparing the as-planned and as-built schedules for a particular project than in comparing the same project to a hypothetically derived case. The advantage of the selected method of analysis is the fact that it avoids the assumptions required to generate the hypothetical case and as such enables a comparison based on actual project records. It is also practical and utilizes a simple and easy-to-follow procedure.

Established facts, extracted from expert reports, on a project that has experienced difficulties, illustrated by several claims, have been considered to depict problem areas associated with fast-tracking. The tight schedule of fast-tracking combined with the size of the project were considered helpful in identifying the coordination and scheduling problems.

Case study

The case study presented here illustrates the critical importance in timing design activities and its inevitable impact on overall planning and scheduling of construction work. Design difficulties in putting work packages together and associated construction delays were examined and assessed to reveal coordination problems when activities are overlapped. In the fast-track project considered in the present study, a distinction is made between the contractor's delays, excusable but non-compensable delays, and fast-track delays originated by the owner. The project has been considered to indentify typical risks and problem areas generally encountered on fast-track projects.

The selected project is a typical fast-track construction of a large industrial plant in the United States with an estimated value of \$100 million. The estimate includes all the procurement contracts, major construction packages, and the design engineering services. The project was originally planned to span 27 months, with a design period of 14 months overlapping the construction phase of 21 months (see Fig. 1). Actually the construction period started 5 months behind schedule and spanned 26.5 months. The plant finally went into operation after a construction delay of 10.75 months, extending the planned project durtation by 40%.

Design and procurement

An engineering firm took over the design development of the plant after significant preliminary work by the owner. Construction work was separated into several self-contained packages each awarded individually to a different prime contractor. In this study, critical work packages were examined in detail with emphasis on the design phase.

Because of the initial difficulties in obtaining the required vendor information and of complications with design coordination, drawings were not completed on time for the scheduled bid dates. As a result, the tendering of the main construction packages was postponed and compressed towards the end of the design period (see Fig. 1). This slippage in bid dates disturbed the original sequence of contract awards and significantly affected the construction schedule.

Trying to meet the intended date of commercial production, the engineering consultant and the owner did not hesitate to reschedule activities, overlap work, and revise activity durations through compression or acceleration. At that time, planning and coordination of the work were severely affected by the fast-tracking approach adopted for the project. Five main packages have been examined for a schedule comparison of tendering period as illustrated in Fig. 2.

Even during tender periods a large number of drawings were revised, added, and deleted in several contract packages. In some cases up to 7 addenda were issued. This resulted, for example, in a slippage of up to 6.5 months in the award of the structural steel package. The bid closing date of this package was delayed three times, 190 drawings were added and 109 drawings were revised. This represented, respectively, 50 and 28% of the number of drawings in the bid package. These last-minute revisions affected the accuracy of the bids and contributed to low-productivity levels in the initial stage. The incomplete design resulted in a large number of drawing revisions required after contract awards (see Fig. 2).

The civil design man-hour histogram and design packages bar chart presented in Fig. 3 clearly show the considerable amount of engineering design required after tender call and award of the contract packages. Typically, two to three more months after award (21% of the planned design duration) were needed to substantially complete the design.

For the civil work (Fig. 3) over 30% of the design man-hours were spent after award of their last contract package. Similar percentages were established for electrical and mechanical works, not shown here. Awarding civil, electrical, and mechanical work packages with incomplete contract drawings and specifications has caused an important increase in total man-hours spent by the engineering firm to finalize the project design.

Construction and completion

According to the original schedule, the project completion date was April 21, 1980, including a construction duration of 21 months (see Fig. 1). The initial delay in design activities resulted in a late start of 5 months in construction. Through further fast-tracking compression, the owner and construction manager were able to reduce this delay to 1 month only.

However, during the construction period, the project suffered an additional 9.75 months delay. This slippage occurred despite an acceleration in the work of both mechanical and electrical contractors through formal orders by the owner.

A detailed schedule analysis has been carried out on the critical activities of the whole project to identify the causes of delay. In determining the critical path, several schedule updates have been examined, each having somewhat different critical paths. It is through this "snapshot" progression of the work that the cause and effect relationship of the delays has been identified. Individual delays have been examined and classified according to their origin.

Parallel critical paths were present throughout the construc-

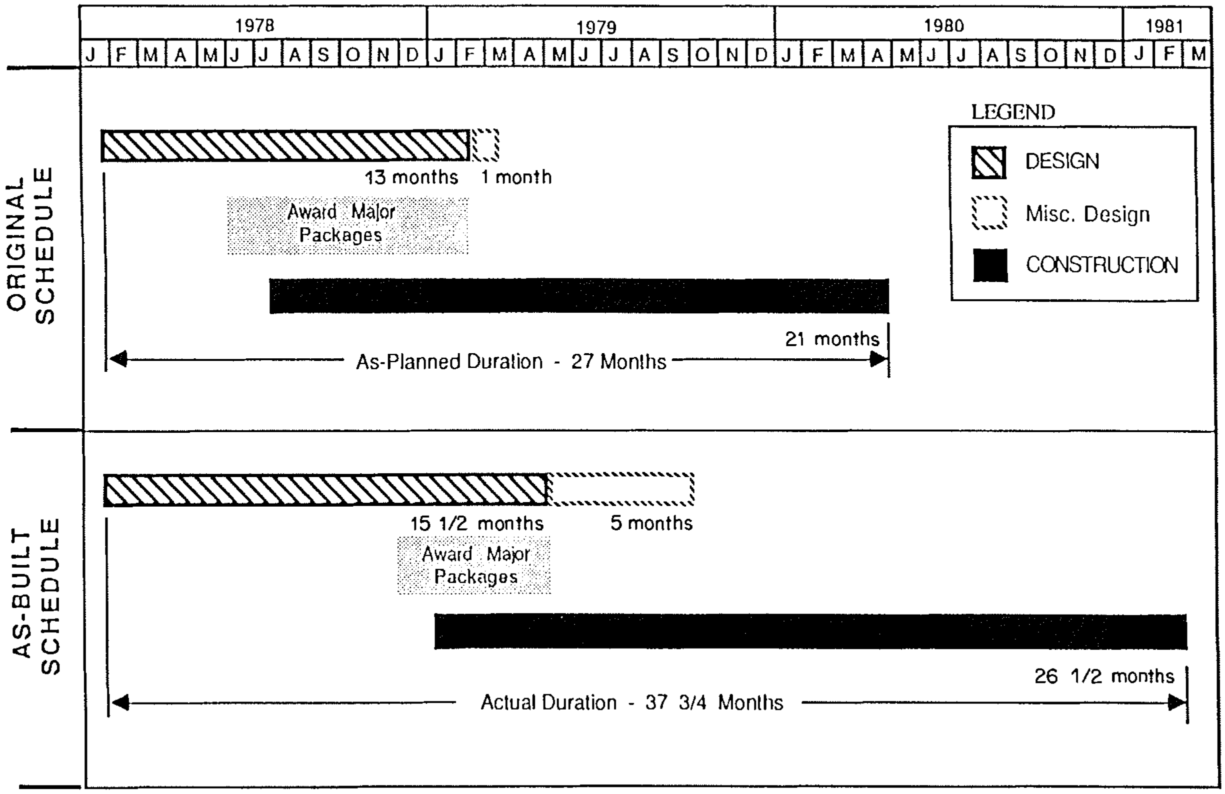

FIG. 1. Summary schedule comparison.

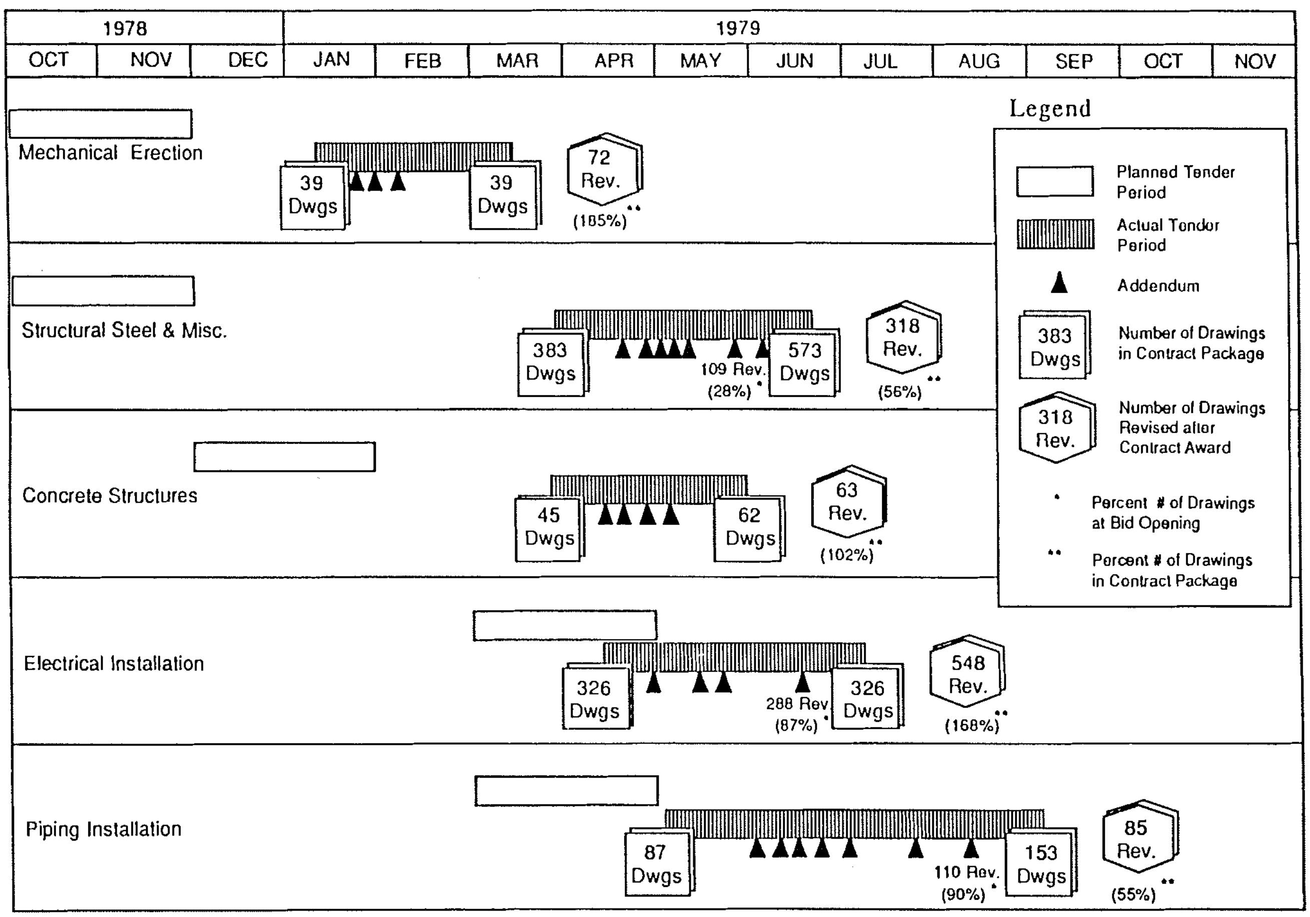

FIG. 2. Schedule comparison of tendering period.

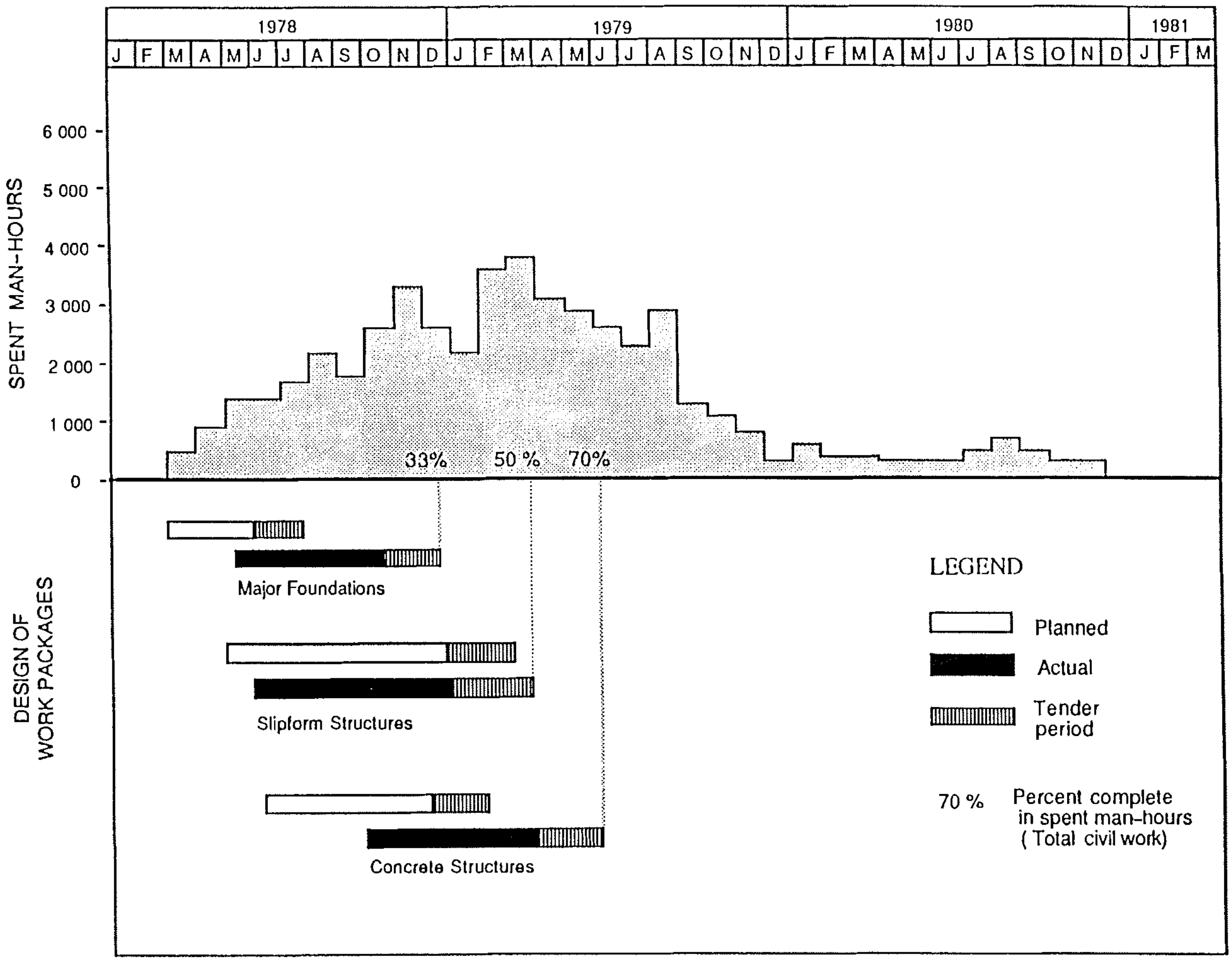

FIG. 3. Civil design man-hours and contract packages.

TABLE 1. Direct fast-tracking delays

Nature of delay	Duration (day)
1. Award of main electrical package	7
2. Additional steel	5
3. Elevator shaft interference	18
4. Additional steel	15
5. Design error–Interference	1
6. Electrical design changes	33.5
7. Revised burner system	22
Total delay	101.5

TABLE 2. Indirect fast-tracking delays

Nature of delay	Duration (day)
1. Late start of platform	34
2. Loss of productivity	52
3. Fabrication errors and rework	26
Total delay	112

tion period. In determining delays, several factors have been accounted for in order to ensure that those delays were in fact on the critical path and did actually delay the project. Concurrent delays were taken into account and overlaps eliminated. Subcritical delays have also been considered, in acknowledgment of the relatively short float (i.e., few days) existing on some of the construction network paths.

For simplicity, fast-track delays have been grouped into two basic categories: (1) delays directly caused by fast-tracking and (2) delays indirectly related to fast-tracking.

Delays directly related to the fast-track approach include the slippage of work packages on the critical path affecting construction start, design errors and omissions resulting from poor coordination between work packages, and design changes attributed to the accelerated approach. Individual delays directly related to the fast-track concept have been identified and allocated as shown in Table 1.

Delays indirectly caused by fast-tracking include trade interferences, work disruptions, and productivity losses. Loss of labour productivity usually reflects the contractor's difficulty to plan adequately because of the numerous revisions of drawings and required extra work. From the schedule analysis, individual delays resulting in productivity losses and disruptions have been summarized in Table 2.

In summary, on the project's critical path a total of 213.5 days out of the 324 days delay period can be attributed directly and indirectly to the fast-tracking approach, representing 66% of the total project delay. Two and three-fourths months (85 days) were identified as excusable delays (rain, strikes, etc.), owner-caused delays, and labour shortage. The total delay of 10.75

TABLE 3. Delay summary on the critical path

Nature of delay	Duration (day)	(month)
Initial delay	26	1
Direct fast-track delay (design related problems)	101.5	3
Indirect fast-track delay (productivity loss and interferences)	112	4
Others (including manpower shortage and excusable delays)	84.5	2.75
Total project delay	324	10.75

months (324 days) represents 40% of the planned project duration of 27 months, while the delay caused by fast-tracking amounts to 26%.

Summary

The case study presented herein illustrates the type of planning and coordination problems one can, and usually would, encounter on a fast-track project.

In light of the design difficulties and the data presented in Figs. 1–3, the impact stemming from drawing revisions can be grouped into (1) delaying call for tenders, (2) extending the tender periods, (3) affecting the contractor's ability to plan and execute his work efficiently, and (4) additional work through change orders.

The above grouping illustrates the possible impact of compressing and overlapping design activities. As a result, the design effort for major contract packages in this plant spanned over a period of 15.5 months instead of the 13 months specified in the contractual arrangement (see Fig. 1).

The construction start was delayed because of tardy input from vendors, lengthy review and revision periods, and design coordination difficulties resulting in a slippage in award of critical contract packages.

The management decision to recuperate the initial 5 months of vendor delays by accelerating both design and construction activities, awarding work packages on incomplete design, and demanding extensive trade overlaps gave rise to a totally opposing result; i.e., the project was further delayed. The extra rescheduling efforts required by project personnel to limit the consequences of this fast-track approach were overridden by the severity of the problems. Additional work and some rework are common in most construction projects, but in this case the fast-track approach seriously amplified the impact of those disruptions as evidenced by their frequency and severity (see Fig. 2). The schedule compression and trade overlaps inflicted a burden on the contractors in terms of available space and restricted time periods to do the work. This in turn gave rise to significant losses in productivity and poor morale among workers.

Accelerating a project through fast-tracking is a major decision, and construction professionals inexperienced in phase or fast-track construction often do not realize what they are getting into. In this particular project, 66% of the total dalays were attributed directly and indirectly to fast-tracking. Spending only two more months (21% of planned design period) on the detailing of design packages before awarding the contract (refer to Fig. 3), would eliminated a major portion of the fast-track-related delays (a maximum of 7 months in this case). Ideally, there would be fewer design errors and omissions. Without the revisions and extra work and subsequent acceleration, the productivity loss could have been significantly reduced, since the contractors would have had the information necessary for proper performance. Trade interferences would have also been reduced to a level where it would not impact the program.

Observations and recommendations

In light of the above study and other studies conducted on fast-track construction jobs that experienced difficulties, trouble areas have been identified. Fast-tracking a project often results in unexpected extra costs and, as observed in this project, does not necessarily lead to a shorter project duration. For the approach to be profitable, particular attention must be paid to the following factors.

1. Design errors and omissions

Fast-tracking construction necessarily means a rearrangement in the design procedures and sequences. With this approach, design work often ends up being done on a rushed basis. In this form, drawings and specifications are often prepared hurriedly, leaving room for a greater margin of errors and omissions.

2. Design changes

With considerable overlapping of work packages and with construction following close behind the completion of each phase of the design, there is less opportunity for design professionals to consider the design as a whole and make design changes, at that stage, without causing delay and increased cost in the field. The increased intolerance of design changes imposes a stringent demand on the performance of design professionals.

3. Coordination between design and construction

With construction activities starting before the completion of all design phases, the process of coordinating basic design work for all disciplines before awarding any contracts is no longer applicable. Consequently, the options of resolving conflicts between the various designs are limited.

4. Coordination between work packages

Besides the fact that contractors are often faced with construction starting on partially completed drawings and specifications, in a fast-track environment a more pronounced overlapping of construction activities would inevitably increase the problem of coordinating work between the various contractors in the field.

The above observations reinforce the statement that managing the interface between design and construction proves to be crucial to the project performance. The inherent risks of fast-tracking projects include (1) the loss of financial benefits due to the cost of changes and claims, (2) the loss of planned time savings due to schedule delays, and (3) the reduction of control over project costs due to the early elimination of design options normally encountered, incomplete tender specifications, and overlapping of the construction work. In an effort to reduce these risks, the following recommendations are made.

1. Spend more effort during the design phase

The far-reaching effect of mistakes during the early design/engineering phase in a fast-track program is usually underestimated. More time and effort, in terms of coordination and planning, should be spent on the design preparation with special attention to trade and (or) work packages interface areas. Early in the design phase, decisions that will limit future flexibility in the design should be highlighted and their impact evaluated. This effort will result in a better and tighter coordination between work packages before they are issued for construction. Although this could be viewed as contradictory to the fast-tracking concept, it nevertheless has to be stressed.

2. Develop an effective design review system

The rushed delivery of drawings combined with an overlapping of work packages will contribute, to a great extent, to an increase in the number of drawings to be revised. At the outset of the project, an efficient review system must be established, with clearly defined channels of communication to compensate for this probable increase in design changes. This precaution would ensure fast and effective review of drawings and would also provide a good interaction between design activities and those performed on site.

3. Increase information input from the field work

Proper timing in awarding different work packages is critical in a fast-track construction. A package issued too late or too early might delay or interfere with another work package. Once construction has started, the award of subsequent work packages must be more sensitive to the ongoing construction activities and the availability of the site. More than just eliminating the impact of issuing work packages too early, this approach will help integrate the latest field conditions in the plans and specifications of the subsequent work packages. This can also considerably reduce revisions after contract award and minimize possible interferences.

4. Increase involvement of participants in all stages of the project

Fast-tracking will be given a chance to succeed only if a real team approach can be reached. The attitude of all participants should be influenced by defining their roles in the project to increase "co-operation." Contractors should be brought in the design phase for scheduling and constructability purposes. A member of the design/engineering team should be appointed full time as design coordinator and work with contractors for an improved response to design-originated problems. Innovative and imaginative contractual arrangement and organizational structures such as PCM should be utilized and enhanced to share responsibilities and authorities. This would eliminate the adversary conditions associated with conventional projects, avoid conflicts, and favor a better exchange of information through well-defined communication channels.

In conclusion, there is nothing new about the individual elements of fast-track construction. What is unique is their innovative combinations. Accelerating a project through fast-tracking is a major decision, and construction professionals should be aware of its implications. Analysis of fast-track construction projects indicated that despite the apparent advantages, not all projects lend themselves to a successful application of the fast-tract approach. Adequate precautions must be taken with respect to the previously identified trouble areas in order to reduce the overall project duration. The project team has to be flexible and expeditious in response to complications stemming from a combination of incomplete designs, with the overlapping of design and construction. Then, even with the high construction costs frequently associated with fast-tracking, overall project profitability could be achieved.

BENNINGSON, L.A. 1972. TREND: new management information from networks. Proceedings, Third International Congress on Project Planning by Network Techniques, Stockholm, Sweden, pp. 44–60.

GRAY, C., and FLANAGAN, R. 1984. U.S. productivity and fast-tracking starts on the drawing board. Construction management and economics, **2**(3): 133–144.

LINTHICUM, G. R. 1982. Contracting: finding the best method. Mortgage Banking, **42**(11): 45–50.

RUBY, D. I. 1978. Fast-tracking plant projects. Plant Engineering, pp. 121–123.

SCHICH, J. C. 1982. Trevino project: a fast-track approach for a small construction project. 1982 Mining yearbook, Colorado Mining Association, pp. 74–79.

SIDWELL, A. C. 1983. An evaluation of management contracting. Construction management and economics, **1**(1): 48–55.

TROMBLEY, S. 1985. Fast-track experience. Building Design, pp. 20–23.

WHITE, A. D. 1980. Coordination problems in fast-track commercial construction. M. A. thesis, Massachusetts Institute of Technology, Cambridge, MA.