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INCENTIVE/DISINCENTIVE CONTRACTS: PERCEPTIONS OF OWNERS AND CONTRACTORS

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ABSTRACT: Incentive/disincentive (I/D) contracting has developed from basic cost- and profit-sharing arrangements between an owner and a contractor. To motivate the contractor to put in an extra effort to realize one or more project objectives of an accelerated, costly, and complex undertaking, the owner may offer an award to the contractor. The owner may also threaten the contractor with a penalty if the objectives are not met. This paper reviews the fundamental incentive/disincentive arrangements in contracting literature. Then, results are reported of a survey conducted on a sample of Illinois DOT highway contracts that included I/D provisions. The survey investigates whether there exists an agreement or disagreement between IDOT's and the contractors' perceptions of I/D contract provisions. The findings reveal how I/D contract milestones are established, how they are executed, what kind of work practices the contractor uses to fulfill I/D targets, and how the contracting parties perceive I/D contracts' effectiveness as opposed to non-I/D contracts. Certain issues pointed out by the respondents as problematic and in need of further refinement in I/D applications are also highlighted.

INTRODUCTION

Incentive/disincentive (I/D) provisions are used in construction contracts to reduce contract cost, to minimize contract duration, and to maintain acceptable levels in the safety, productivity, technological progress, innovation, management efficiency, and quality of construction. I/D contracts transfer some of the risk traditionally associated with the owner to the contractor, in return for a reward given if the contractor is able to achieve the target set in the contract. Incentives are generally used along with disincentives to promote efficient contract management and to reward only successful contractors with high performance standards who are able to meet the owner's objectives.

I/D provisions are not used extensively in public infrastructure projects. The Illinois Department of Transportation (IDOT) has, however, used I/D provisions in numerous contracts to encourage early completion, e.g., on projects where large volumes of traffic are inconvenienced by ongoing construction or where major river structures must be closed resulting in considerable adverse travel distance. In these contracts, the incentive and disincentive amounts are based on the sum of the road user delay costs and liquidated damages. According to IDOT records, most contractors realized incentive payments near the maximum limit; the incentives that have been paid out by IDOT have exceeded the assessed disincentives by 30 to 1 in the I/D projects undertaken up to 1992.

The main objective of this study is to compare owners' (IDOT) and contractors' perceptions of I/D contract provisions and to identify the underlying facts in I/D applications. The results of a survey to identify IDOT's resident engineers' and contractor superintendents' perceptions of I/D implementation are presented after a general overview of the currently existing incentive models. The areas investigated include the process of establishing I/D milestones, the implementation of I/D provisions, contractors' work practices associated with I/D contracts, and the perceptions of the contracting parties on the effectiveness of I/D versus non-I/D contracts. A final section is devoted to highlighting certain issues that have been identified as impeding I/D applications by the majority of the respondents.

I/D MODELS

The classical application of incentives in contracts is in the form of cost incentives. The traditional formulation of incentive contracting is as follows (Scherer 1964):

$$F_c = F_t + k(C_t - C_a) \tag{1}$$

where F_c = contractor's realized profit; F_t = negotiated target profit; C_t = negotiated target contract cost; C_a = actual contract cost; and k = sharing ratio ($0 < k < 1$).

As is clearly seen, in incentive contracts, the amount that the contractor saves on the contract is shared by the owner and the contractor. The two extremes on the values of k, 0, and 1, reflect the cost-plus-fixed-fee and the firm-fixed-price contracts, respectively. Any value of k in between these extremes would mean that incentive contracting is being used.

The first term in the right-hand side of (1), F_t, is the negotiated fee that has been agreed to by the parties at the time the contract is signed; therefore, it is constant. The contractor's objective is to maximize the value of the cost outcome. If the actual contract cost, C_a, is decreased, this indicates the contractor's efficiency in cost reduction. On the other hand, if the target contract cost, C_t, is inflated, this would imply a cost underrun, which actually is not a cost saving on the owner's part and should be avoided. Setting a realistic target cost in incentive contracts is as important an issue as cost efficiency during construction. Fisher (1969) also points out that incentive contracts motivate contractors to reduce actual costs, but they also encourage them to inflate target cost estimates. After conducting regression analysis, he concludes that the sharing rate, k, has no effect on underruns, a conclusion that seems to contradict Sherer's (1964) expectation that the contractor's expected profit should be dependent on k. Fisher (1969) also concludes that underruns are not related to the pricing provisions of the contract. He adds that realistic and tighter target costs should be established for incentive contracts to be motivational.

The gambling aspect of incentive contracting is introduced by Bradley and McCuiston (1972), who conclude in their study that the incentive fee arrangement provides the contractor with a mechanism for optimizing its fee outcome given the target cost. According to them, this is the reason for the transition from cost-plus-fixed-fee to the incentive form of contracting.

Early research studies on incentive contracting were con-

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ducted on a theoretical level and, because of limited data, were mostly exploratory (DeMong 1978). As experience with I/D applications increased, more data became available for empirical analysis. Lately, the construction industry has started diverting some of its research interest into the study of incentives and disincentives as a means to improving contracting techniques and developing more efficient and effective project management methods (Ashley and Mathews 1985; Ashley and Workman 1985; Ibbs et al. 1986; Ibbs and Abu Hijleh 1988; Jaraiedi et al. 1995). More recent studies have started discussing the results of I/D applications and other innovative contracting methods (Herbsman et al. 1995; Arditi et al. 1997). In addition to these studies, economists and accountants have performed in-depth analyses of I/D contracting using statistical methods and differential calculus. They have tried to determine the micro- and macro-economic effects of incentives, to analyze the utility curves and opportunity costs associated with them, to simulate bidding models, and to explore the impact of the agency theory in designing incentive contracts (Bernhard 1988; Androkovich 1990; Cohen and Loeb 1990; Brumm 1992; Reichelstein 1992).

The overall literature on I/D contracting mainly encourages its application, provided that it is not redundant for the related project and that an accurate analysis of associated costs and durations is performed. It is important for the success of I/D contracts that the objectives and risks of both owner and contractor be fully explored. Yet one of the essential postulations of I/D contracting, which is the benefit of early completion due to the fast-track nature of these contracts, was considered by Rosenfeld and Geltner (1991) to be overstated.

The major objective featured in the profit-sharing formula in (1) is minimizing cost. However, depending on the level and scope of risks accompanying a certain project, other contract types that stimulate different motives may be more appropriate.

Schedule incentives in fixed-price contracts are in the form of bonus/penalty related to the completion date. The application is very simple, involving an addition per each day of early completion and a deduction per each day of late completion (Stukhart 1984). The I/D amount mentioned here should be realistic and attainable to motivate the contractor. It has been stated that there is a motivation on the contractor's side "to fulfill his responsibilities on time," as he/she does not want to be recorded for lateness (*Incentive* 1969). Also, delays usually increase costs, causing overruns, and early completions tend to decrease costs, resulting in underruns (DeMong 1978). It is important for the project management team to identify projects that will contain schedule incentives with the utmost care. As Abu Hijleh and Ibbs (1989) noted, "If the planned project is one for which early completion produces a sizeable and early return on investment, the owner can afford to share a portion of the expected benefits and create an incentive for the contractor."

A disincentive clause is not a liquidated damages clause, which is a basic tool of current construction contracting practice. The enforcement and threat induced by liquidated damages is very subtle when compared to that of disincentives. Disincentives are larger in amount and accompany incentives, whereas liquidated damages are used to collect losses incurred by the owner in case of delays.

Another type of I/D application is a combination of cost and schedule incentives and disincentives (Stukhart 1984). This pattern includes a bonus/penalty scheme for underrun/overrun of target dates and another for underrun/overrun of project cost. The purpose of these combined contract incentives "is to motivate the contractor to produce a system that will meet or surpass performance goals, on or before a target date, and within or at a target cost" (Finchum 1972). When using combined incentives, care should be taken not to overemphasize a particular incentive, as this might cause an imbalance in the contractor's priorities and therefore harm the owner's interests.

Performance incentives or disincentives are used to reward or penalize contractors depending on the attainment of targets other than time or cost (Ibbs and Abu-Hijleh 1988). Examples of the most widely used performance parameters as incentives and/or disincentives include safety, quality of construction, responsiveness, technical management, business management, and utilization of resources (Stukhart 1984). Performance parameters may have a significant impact on the construction cost and schedule. This type of contract provision is more effective if used as a reward, not a penalty.

Another innovative contracting approach known as "A + B Bidding" incorporates into the bid the daily incentive amount (expressed as the road user cost) and the contractor's anticipated project duration. In "A + B Bidding," bids are evaluated by the owner according to the following formula. The bidder with the lowest offer, C, is awarded the contract.

$$C = A + (B \times r) \tag{2}$$

where C = contractor's offer; A = contractor's estimate of the dollar amount of the work to be performed; B = contractor's estimate of the total number of calendar days for completing the work; and r = road user cost ($/day).

In FHWA applications, $5,000 per calendar day is the stipulated adjustment for road user costs, r ("I/D" 1989). Here, it should be noted that mobilization and demobilization durations are omitted from project duration, B. Also, the maximum amount of bonus is limited to 5% of the awarded contract price. If the contractor fails to complete the contract on time, he or she will be subject to paying liquidated damages. The amount paid to the successful contractor is limited with A; C is calculated only for the purpose of selecting the contractor. Herbsman (1995) discusses this method in detail.

RESEARCH METHODOLOGY AND DATA ANALYSIS

The study involved preparation of a questionnaire to conduct a survey of IDOT and general contractor personnel involved in the management of ongoing or recently completed IDOT projects. The questionnaire was designed to reveal the methodology by which I/D targets are established, how I/D contract provisions are implemented throughout the lifecycle of a project, the work practices contractors use to fulfill I/D targets, and how the contracting parties perceive the effectiveness of I/D contracts as opposed to non-I/D contracts. The analysis is conducted by comparing the distributions of the answers of both parties to the survey questions and testing a series of hypotheses of whether the two contracting parties agree on their perceptions of different aspects of I/D contract applications. A copy of the original questionnaire is presented in Appendix I.

The sample of projects used in this study was obtained from IDOT listings of ongoing and recently completed I/D contracts. The I/D provisions in all the I/D projects contracted out by IDOT were always "schedule-incited." These lists included the names and telephone numbers of IDOT's resident engineers (hereafter referred to as RE) and contractors' superintendents (hereafter referred to as SI) involved in these projects. They included information about a total of 21 contracts, of which 13 had already been completed in 1994. Attempts were made to contact all of the REs and SIs who worked on these projects. The questionnaires were administered by personal interviews, mailings, and telephone interviews according to the preference of the respondents and their geographic location. The sites of the ongoing projects were visited, and most

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of the REs and SIs were interviewed on site. The survey was administered to 18 REs and 12 SIs. The remaining REs and SIs could not be located or declined to cooperate.

All questions, with the exception of questions 2, 6, and 22, are of the multiple choice type, where the respondents are requested to pick the most relevant answer out of several on the basis of their experiences involving recent or ongoing I/D contracts. The data collected consists of nonnumeric observations occurring in n pairs, where n is the number of possible answers to each question. The data are ranked according to the degree of preference attached to the observations, with the most frequently marked answer ranked the highest. In situations where ties existed, the average of the ranks that would have been assigned to the tied value, had the tie not existed, was calculated and allocated to each tied value. Then, the Spearman rank correlation coefficient, denoted by r_s, is calculated as a measure of correlation between the distribution of the parties' answers to each question. The formula for the calculation of r_s is as follows (Conover 1980):

$$r_s = 1 - 6T/n(n^2 - 1)$$

where r_s = Spearman rank correlation coefficient; $T = \Sigma\,[R(X_i) - R(Y_i)]^2$; n = sample size or number of observations occurring in pairs; $R(X_i)$ = rank of X_i as compared with other X values for $i = 1, 2, \ldots, n$; and $R(Y_i)$ = rank of Y_i as compared with other Y values for $i = 1, 2, \ldots, n$.

The null hypothesis that "SIs and REs do not agree (are not correlated) on their perceptions; i.e., $r_s = 0$" is tested against the alternative hypothesis that "SIs and REs agree (are correlated) on their perceptions; i.e., $r_s \neq 0$" at the 95% confidence level, when data are adequate to pass a judgment, i.e., when the number of observations are greater than or equal to five. The Spearman correlation coefficients and critical r_s values for these questions are reported in Table 1. When the number of observations are less than five, only the percentage distributions of the responses of REs and SIs are reported. The results of the statistical analysis must be considered with caution because of the limited size of the sample.

TABLE 1. Spearman's Rank Correlation Coefficients

Question number (1)	r_s[a] (2)	$\pm r_c$[b] (at 0.05 significance) (3)
1	0.857	0.829
2	0.668	0.485
3	−0.279	0.829
4	1.000	N/A[c]
5	0.750	N/A[c]
6	0.894	0.829
7	0.900	0.900
8	0.500	N/A[c]
9	0.750	N/A[c]
10	−0.100	N/A[c]
11	1.000	0.900
12	0.845	0.714
13	−0.129	0.829
14	0.575	0.900
15	0.786	0.829
16	0.730	0.636
17	0.714	0.829
18	0.800	N/A[c]
19	−0.575	0.900
20	0.875	N/A[c]
21	−1.000	N/A[c]
22	N/A[c]	N/A[c]

[a]r_s = Spearman correlation coefficient.
[b]r_c = Spearman correlation coefficient (critical).
[c]N/A = Not applicable.

SURVEY FINDINGS

As mentioned earlier, the main objective of the survey was to determine the REs' and SIs' agreements or disagreements in their perceptions of the implementation of I/D clauses in highway construction contracts. In some instances, the answers given to the same question by REs and SIs deviated considerably from each other, indicating a significant discrepancy in perceptions. The answers to some other questions were in agreement. A discussion of the findings of the questionnaire is presented under the following four headings: I/D contract milestone setting (questions 1, 11, and 18), I/D project implementation (questions 2 and 3, and 6–9), contractors' I/D-related work practices (questions 12–17, and 19), and comparison of I/D versus non-I/D contracts (questions 4, 5, 10, 20, and 21). At the end of the discussion, a section is devoted to pinpointing issues that were deemed problematic and/or ambiguous in I/D applications by the parties involved (question 22). All I/D contracts led by IDOT that were covered in this study involved only schedule incentives and disincentives and no other types of I/D.

I/D Contract Milestone Setting

Target Project Duration for I/D Contracts

A critical problem in a "schedule-incited" project is the accurate determination of the target contract duration by the owner prior to advertising the project. The accuracy of the target duration is crucial, as incentive payments or disincentive charges will be made by using the target contract duration as a benchmark. If the target contract duration is underestimated, the project will lose its incentive characteristic. On the other hand, if the target contract duration is overestimated, then there will not be real savings for the owner and, consequently, for the public. Therefore, the contract completion date should reflect the expedited completion time that is attainable by the contractor and should be arrived at by using appropriate scheduling techniques, not arbitrarily.

The method most frequently used by IDOT to calculate I/D (and non-I/D) project duration is based on reviewing similar past projects and proceeds as follows. After the quantity take-off of the project is completed by the IDOT design bureau, durations for major activities are determined by using the Daily Production Table in the IDOT design manual. Next, the critical activities which typically control the pace of the construction in similar projects are selected. These activities are then plotted on a bar-chart, which becomes the initial work schedule of the project. In May 1992, an IDOT committee was established to review the daily production rates specified in the design manual. These rates had not been revised in over ten years. Considering the current technology and equipment, the numbers no longer reflected reality. The Daily Production Table was reviewed by using input from design and construction engineers representing all districts in Illinois. High and low margins were set to allow for differences in districts, weather conditions, locations (urban or rural), and high volume roads, but no specific instructions were issued regarding the selection of appropriate production rates from within the specified ranges. Rather, this decision was left to the expertise and intuition of the person in charge of the project at this stage. This method of project duration determination is also referred to as "determination of I/D time using past performance" in FHWA *Technical Advisory T 5080.10* ("I/D" 1989). Another method that is recommended in this technical advisory but not frequently utilized by IDOT is the use of CPM (Critical Path Method).

When using past performance in estimating project duration, two schedules are made, namely, normal and expedited. The

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"normal schedule" is based on a 5-day week and an 8-hour day. This schedule is then compressed into an "expedited schedule" with 6 or 7-day weeks and extended working hours ("I/D" 1989). Another alternative when developing an expedited schedule is to pick higher daily production rates. Because it is anticipated that extensive manpower and equipment will be used to realize "early completion," it is apparent that the daily production rates of the activities would be higher than usual. The project duration could be realistically calculated if higher daily production rates are taken into account in addition to longer working hours per day and working days per week.

Evaluating the effects of expediting a project on project costs can be achieved by performing project compression on a CPM network (Antill and Woodhead 1990) if utility data are available and reliable. However, IDOT did not perform any advanced scheduling analysis such as CPM in the determination of project durations, even for the highly visible I/D projects.

The results presented in Fig. 1 indicate that there is total agreement between SIs and REs that formal or informal contractor input is not used by IDOT in determining project duration; however, there is confusion regarding how target project durations are actually determined by IDOT. Indeed, answers to question 1 indicate that 67% of the contractors did not know how the contract duration is calculated by IDOT; as many as 30% of REs did not know the answer to this question, either. Another 50% of REs indicated that the target contract duration is based on data obtained from similar past projects (as described in the above paragraphs); but only 25% of the contractors thought the same.

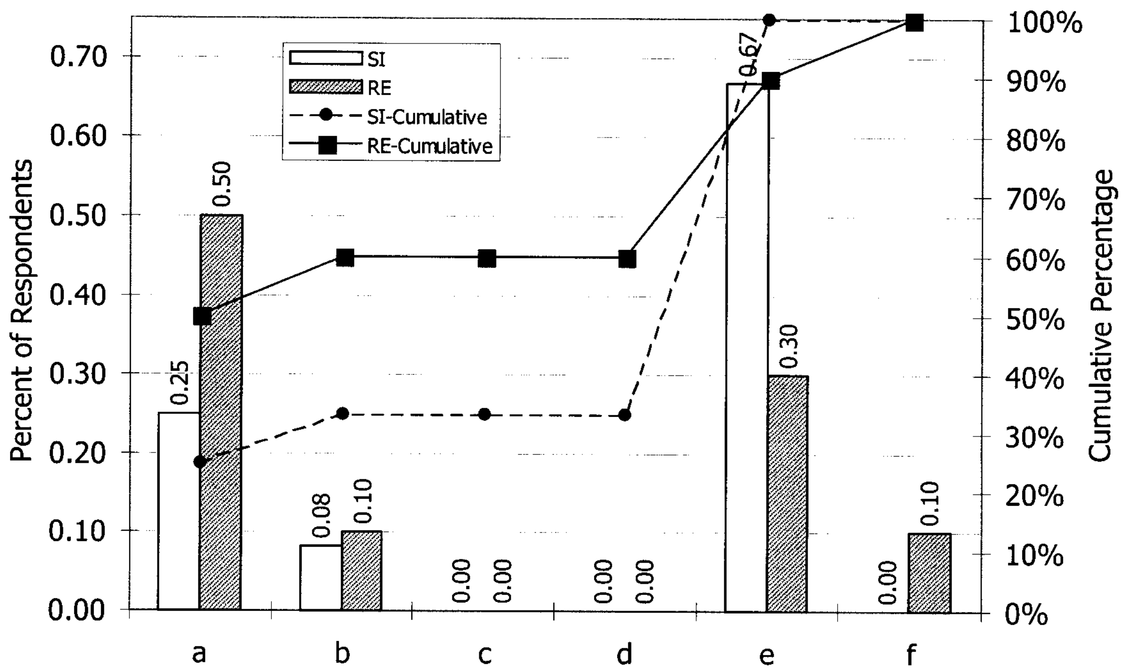
The r_s correlation coefficient between the SIs' and REs' rankings of the choices to question 1 is calculated as 0.857. The use of this statistic to test the hypothesis that "SIs and REs do not agree on the method of project duration calculation by IDOT in I/D projects" is rejected at 95% confidence level (r_s critical = 0.829), leading to the conclusion that there is a statistically significant agreement in the parties' perceptions regarding the calculation of project durations for I/D projects.

I/D Project Completion

One of the important aspects in I/D provisions is the definition of project completion (question 11). About half of the respondents (45% of SIs and 56% of REs) agreed on the general definition of project completion as "unrestricted traffic is permitted (cleanup and demobilization not included)." For about a quarter of the respondents (36% of SIs and 22% of REs), a project was considered complete at substantial completion, which also corresponds to the time when unrestricted traffic is permitted to flow and only in consequential portions of the work are missing and/or only minor repairs are necessary. The Spearman rank correlation of a perfect 1.00 between the SIs' and the REs' answers indicates that there is total consensus among the parties regarding the criterion of project completion. Once the contractor earns the incentive, answers to question 18 show that the payment is mostly made in full upon completion of all the work (67% of SIs and 82% of REs) or upon completion of milestone activities (25% of SIs and 6% of REs), depending on the nature of I/D provisions used in the contract. The ranking of REs' and SIs' answers to this question also results in an r_s value of 0.800, which indicates harmony in the perceptions of both parties, but further hypothesis testing is not conducted because of the limited number of observed points in this question.

I/D Project Implementation

I/D contracts are basically fast-track projects that have been accelerated to achieve the earliest possible completion. In this process, the cost is meant to be kept within a reasonable range. Under this type of contract, a contractor that achieves time savings and performs a safe and acceptable job earns a bonus,



(a) Based on similar projects
(b) Based on an analytical model developed for this purpose
(c) With informal input from contractor
(d) After formal negotiation with the contractor
(e) Don't know
(f) Other (please specify)

FIG. 1. Establishing I/D Project Duration

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whereas a contractor that is delayed due to contractor-related causes pays a penalty.

I/D Project Objectives

When respondents were asked in question 6 to rank the objectives of an I/D contract, REs ranked schedule as the first target and cost as the fourth, whereas contractors ranked cost as the first target and schedule as the fourth. It was surprising to see that in a schedule-incited project, contractors had ranked schedule as the fourth target. It seems that I/D implementation is perceived by contractors only as a profit-enhancing tool. The idea behind using I/D provisions should be better conveyed to the contractors in order to achieve contract goals that are beneficial to all parties involved. There seems to be agreement in the ranking of the remaining factors. The ranking with respect to parties and their weighted averages on a scale of 1 to 6 are shown in Table 2. The Spearman's rank correlation is calculated as $r_s = 0.894$, implying that REs and SIs generally agree on their perceptions of the importance of the project objectives.

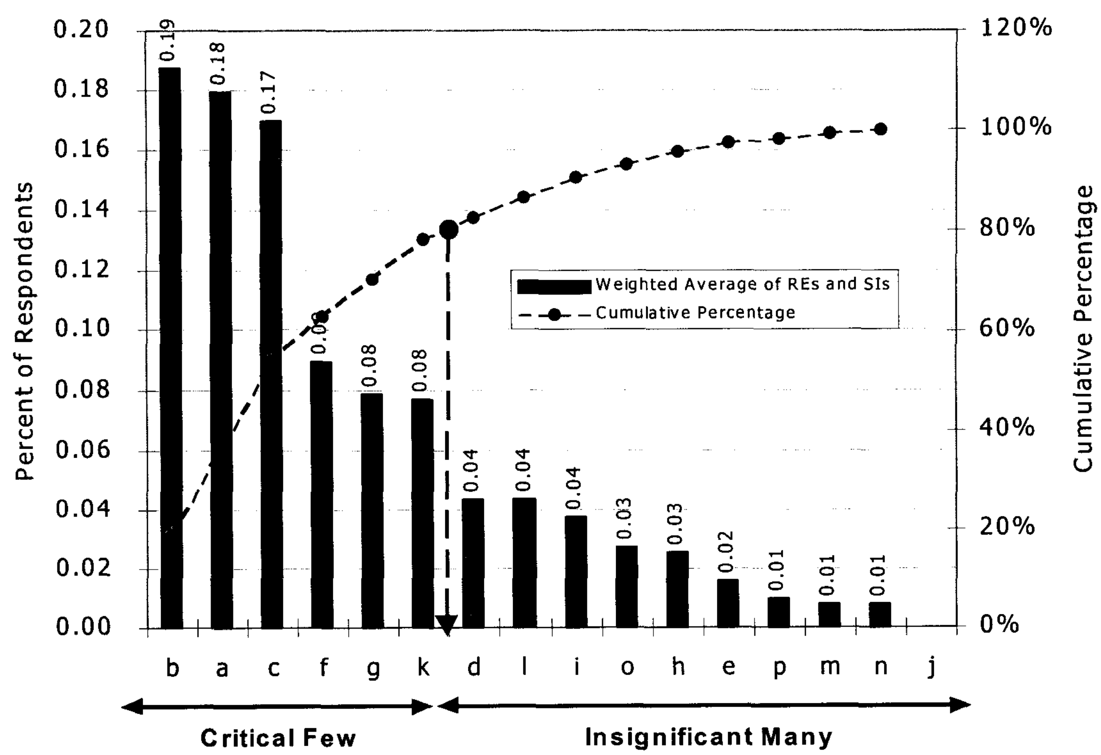
TABLE 2. I/D Objective Ranking

Superintendents (SI)		Resident Engineers (RE)	
Objective (1)	Ranking (2)	Objective (3)	Ranking (4)
Cost	2.11	Schedule	2.14
Safety	2.44	Quality	2.36
Quality	2.67	Safety	3.07
Schedule	2.73	Cost	3.64
Management	4.33	Management	4.86
Technology	4.44	Technology	4.93

Note: 1 = most important; 6 = least important.

I/D Project Identification

The need for including I/D provisions in construction contracts may originate from a variety of reasons. IDOT *Design*



(a) High visibility project
(b) High volume road
(c) High road user delay cost
(d) Severe disruption on adjacent businesses
(e) Project with direct bearing on project start and/or interruption of progress on major freeways, arterials or structure
(f) Project involved with major reconstruction of an existing highway
(g) Project with benefits, in terms of cost savings and/or safety that outweigh the cost of incentive payments and additional construction costs.
(h) A part of a contract that can be done well before the rest of the work, and is of significant benefit to the public
(i) Project was a prerequisite to the use of some other projects (eg.: filling a gap or removing a serious bottleneck)
(j) Project was needed by a specific date to provide service to some other traffic generator (eg.: a new school)
(k) Project involved the prolonged closure of one or more highway lanes
(l) River Structure in or adjacent to central business district
(m) Night time construction on major urban freeway
(n) Part of a cooperative I/D project application
(o) Don't know
(p) Other (please specify)

FIG. 2. Reasons for Including I/D Provisions in Contracts

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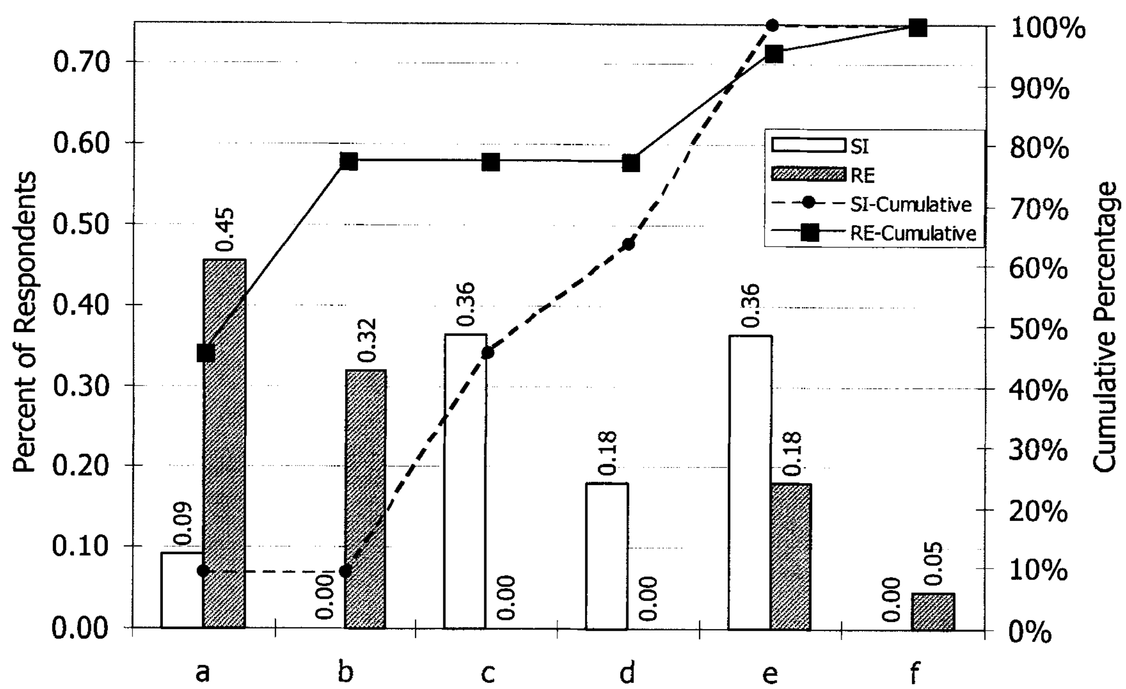
Memorandum 90-53 (1990) has been used in the preparation of question 2 as a major source of potential reasons why I/D provisions should be used in contracts. A Pareto analysis of the weighted averages indicates that six reasons are cited 79% of the time; these reasons, referred to as the "significant few" in Pareto analysis, are shown in Fig. 2 in descending order of frequency. These six reasons, namely, high visibility project (19%), high volume road (18%), high road user delay cost (17%), major reconstruction of existing highway (9%), project benefits exceeding incentives (8%), and prolonged lane closure (8%), can be used as a checklist to determine whether the inclusion of I/D provisions in a contract is appropriate for a project. The remaining ten reasons, which constitute 21% of the total, seem to be project specific and appear to have been selected by the respondents because of the unique nature of the associated projects. They are also known as the "insignificant many" in Pareto analysis. The hypothesis that the two parties generally agree on the major reasons is also verified by a Spearman rank correlation coefficient of $r_s = 0.668$ (Table 1).

There seems to be a major inconsistency in the parties' perceptions of the stage at which I/D provisions are included in a contract (Fig. 3). In answering question 3, more than 75% of REs claimed that these provisions were included in the planning or design stages, whereas less than 10% of the contractors shared this claim. More than 50% of the contractors thought that these provisions were included at a later stage, such as the bidding or construction stages. The Spearman rank correlation, r_s, for this question is -0.279, supporting the acceptance of the hypothesis that "SIs and REs do not agree on their perceptions regarding the stage at which I/D provisions are included in a contract" (Table 1). It appears, therefore, that contractors are not well informed of when I/D provisions are included in a contract. Research conducted independently of this study shows that I/D provisions are always introduced at the early stages of a contract (Yasamis 1994).

IDOT and Contractor Communications

One of the effects of including I/D provisions in a contract is to transfer risk from the owner to the contractor, accompanied by a compensatory bonus scheme. A disadvantage of fixed price contracts (of which unit price contracts are a variation and the most commonly used contract type by IDOT) is that it puts the owner and the contractor in adversarial roles ("Contractual" 1982). With the addition of I/D provisions and the consequent risk transfer to this scenario, the hostility between the parties is likely to increase. One solution to this problem would be to maintain good lines of communication between the parties and to share the same objectives to guarantee that all parties involved benefit from the contract. The most common ways of establishing lines of communication are reported in question 7 and include preconstruction meetings (44% of SIs and 39% of REs), followed by regular meetings (28% of SIs and 32% of REs) and informal communications between the owner and the contractor in the construction stage (22% of SIs and 21% of REs). There is almost no predesign communication between the parties (6% of SIs and none of the REs). The Spearman rank correlation of 0.900 also indicates that the agreement between SIs and REs in this matter is strong (Table 1). The writers believe that the development of early communications, even at predesign or design stages, could help attain schedule targets because of the unique nature of I/D contracts.

The study shows a major discrepancy in the perceptions of parties when it comes to the negotiation of I/D provisions. In answer to question 8, 77% of the REs claimed that I/D provisions are negotiated in preconstruction or construction meetings, whereas 73% of the SIs claimed that they are not ne-



(a) At the planning stage
(b) At the design stage
(c) At the bidding stage
(d) At the construction stage
(e) Don't know
(f) Other (please specify)

FIG. 3. Project Stage at which I/D Clauses Are Introduced into Contract

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gotiated in these meetings. However, the distribution of the answers to question 9 indicate that most respondents (64% of SIs and 44% of REs) believe that no disputes are caused by contractors' objections to I/D provisions. Only 18% of SIs and 38% of REs reported the occurrence of disputes caused by complications introduced by I/D provisions. The remaining respondents did not know whether such disputes occur or not. The discrepancy between perceptions regarding I/D negotiations and their implications on creating disagreements remains fuzzy and deserves further consideration.

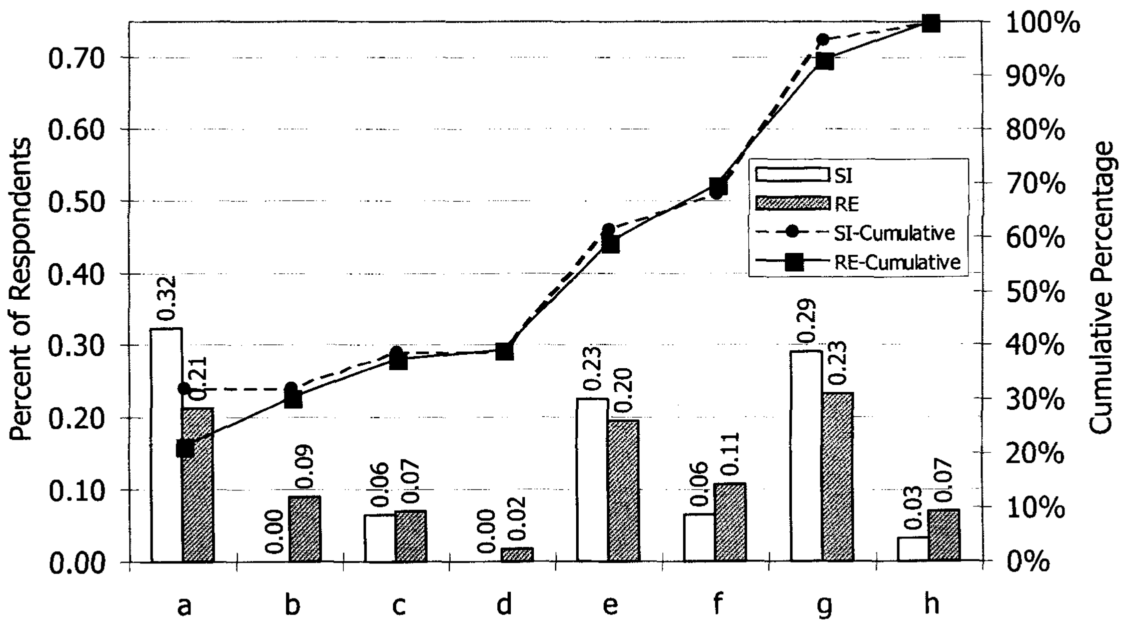
Contractors' Work Practices

Question 12 was asked to test the expectation that a contractor undertaking an I/D contract would work longer hours with increased manpower and equipment in order to achieve the early completion target. The findings are presented in Fig. 4 and show that the most frequently used methods by contractors to attain this target are a 6-day work week, extended work hours with 12–14 hours per day, and multiple work crews in multiple areas. The SIs' and REs' answers to question 12 are positively correlated, with an r_s value of 0.845, indicating that REs and SIs agree on their perceptions of the expedited work schedule schemes used by contractors (Table 1).

It was also anticipated that contractors would experience difficulties in implementing expedited work schedules due to limitations contained in most labor agreements. As reported by the SIs in question 13, the most problematic areas appear to be adjusting scheduled overtime and increasing labor productivity, each pointed out by 40% of the respondents (Fig. 5). The differences between SIs' and REs' perceptions are an indication that REs are not aware of and/or do not appreciate contractors' struggle in this matter. The insignificant r_s value of -0.129 also supports the hypothesis that the parties do not agree on whether the contractor experienced difficulties during I/D application due to labor agreements (Table 1). At this point, the larger number of "Do not know" answers given by the REs (53%) to question 13 needs to be highlighted.

In answer to question 14, it was surprising to see that most contractors (38%) try to achieve project goals by extreme compression of activities towards the end of the project, whereas few (25%) implement technological or managerial novelties (Fig. 6). Ad hoc measures are used by 19% of the contractors when deemed necessary. The few contractors that implemented technological or managerial improvements indicated when answering question 15 that they do so mostly in the form of advanced equipment (40%) and advanced construction methods (30%). Advanced construction management techniques (20%) and advanced materials (10%) play a less significant role in achieving I/D targets. It is surprising that the Spearman rank correlation analyses conducted for questions 14 and 15 yield correlation coefficients of 0.575 and 0.786, respectively, and indicate that there exists no agreement in the perceptions of SIs and REs regarding the general measures taken by the contractor to fulfill I/D targets and the adoption of technological and managerial improvements by the contractors. There is no reason to doubt the accuracy of the SIs' answers to questions 14 and 15, because these questions are directly related to contractors' activities. The fact that REs disagree with the SIs' answers indicates that REs are not cognizant of the strategies that contractors use to achieve target durations and, hence, of their implications on the quality of the work performed.

In response to question 16, 48% of REs thought contractors use CPM methods for project management (Fig. 7). However, only 30% of the contractors declared using CPM whereas 39% used bar-charts. This might imply a tendency on the contractor's part to conform to IDOT's method of project management, which includes bar-charts exclusively. Other managerial practices such as time-cost trade-off, resource allocation, repetitive scheduling techniques, computerized inventory con-



(a) Six day work week
(b) Seven day work week
(c) Double shift
(d) Triple shift
(e) Extended work hours with 12-14 hours per day
(f) Expedited work schedule with 228 working days per calendar year
(g) Multiple work crews in multiple areas
(h) Other (please specify)

FIG. 4. Contractors' Work Schedule

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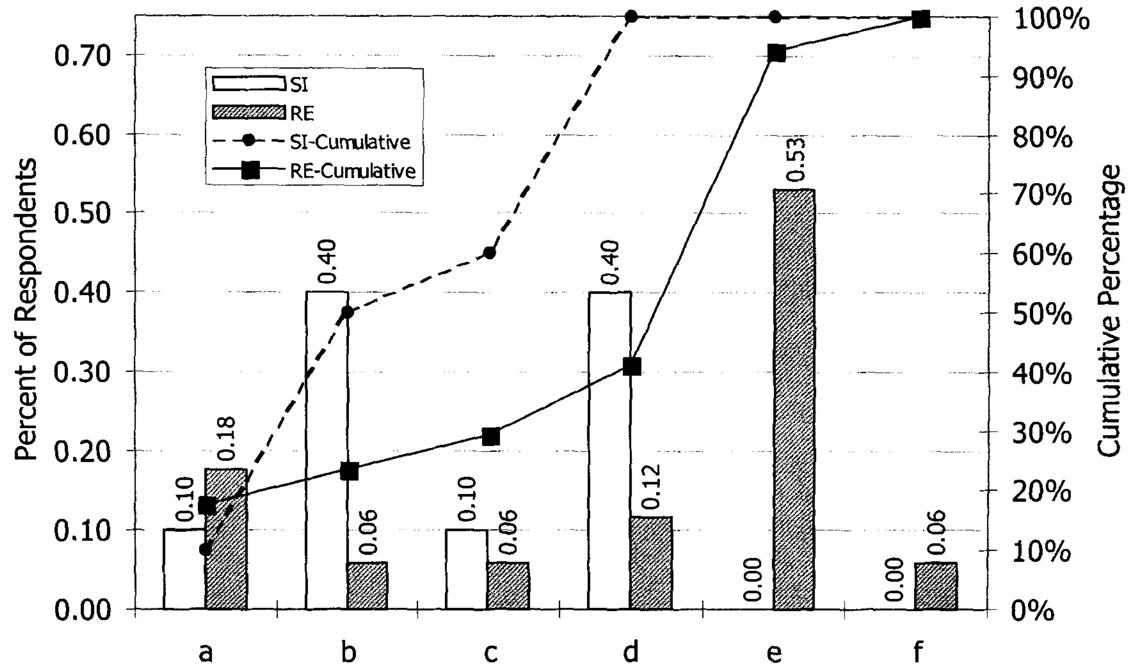
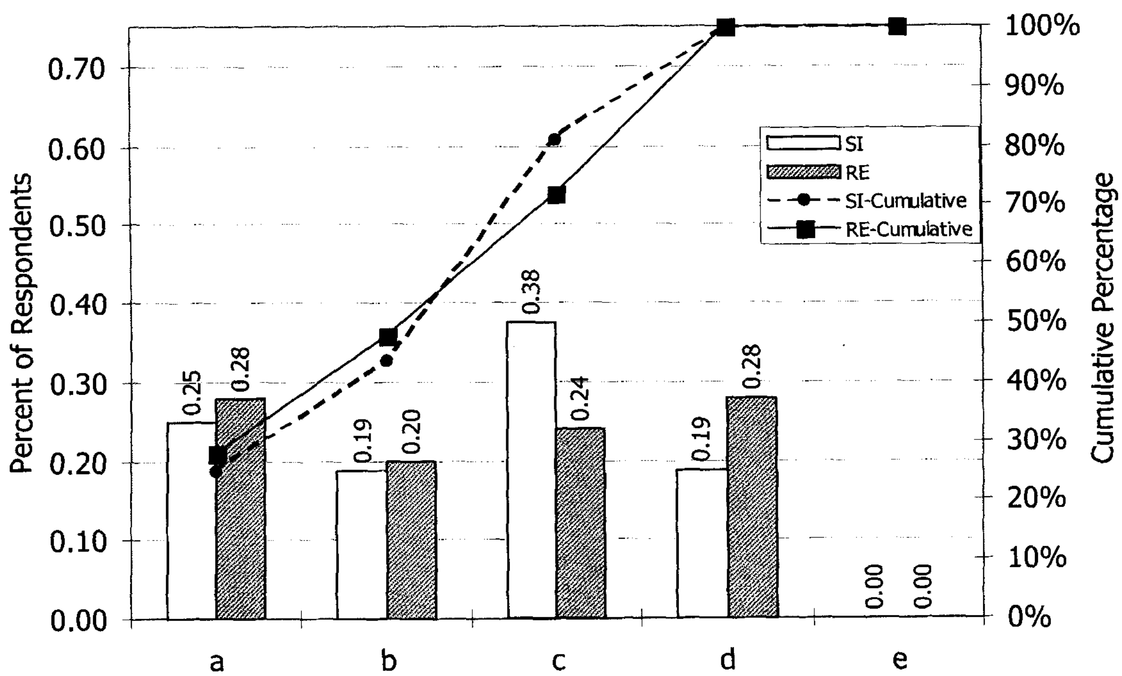


(a) Optimizing crew sizes
(b) Adjusting scheduled overtime
(c) Setting wages in second or third shifts
(d) Increasing labor productivity
(e) Don't know
(f) Other (please specify)

FIG. 5. Difficulty with Labor Agreements



(a) Planned technological/managerial novelties
(b) Ad hoc measures as necessary
(c) Extreme compression of activities towards the end of the project
(d) Don't know
(e) Other (please specify)

FIG. 6. Measures Taken by Contractors to Achieve I/D Targets

trol, computerized equipment management, and electronic information flow are used rather infrequently by contractors. The Spearman rank correlation test results in a correlation coefficient of 0.730, indicating a reasonably high conformity in the perceptions of the parties (Table 1).

Answers to question 17 indicate that 40% of the contractors reported adopting special considerations in selecting subcontractors and field personnel to achieve I/D targets (Fig. 8). Special qualifications sought in subcontractors may include the ability to perform with great speed, prior experience with I/D

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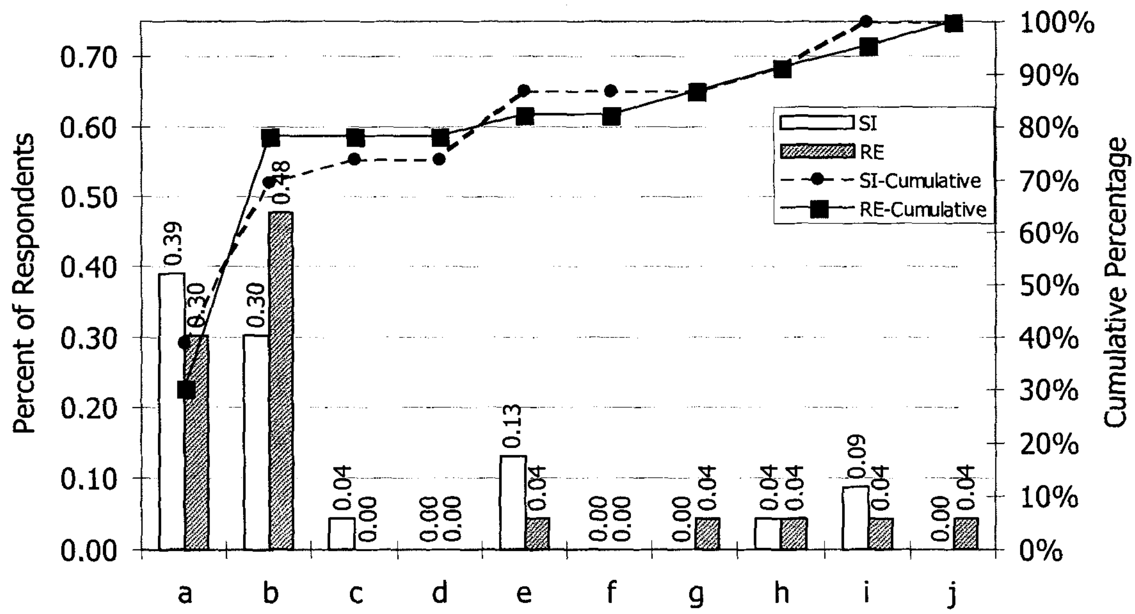
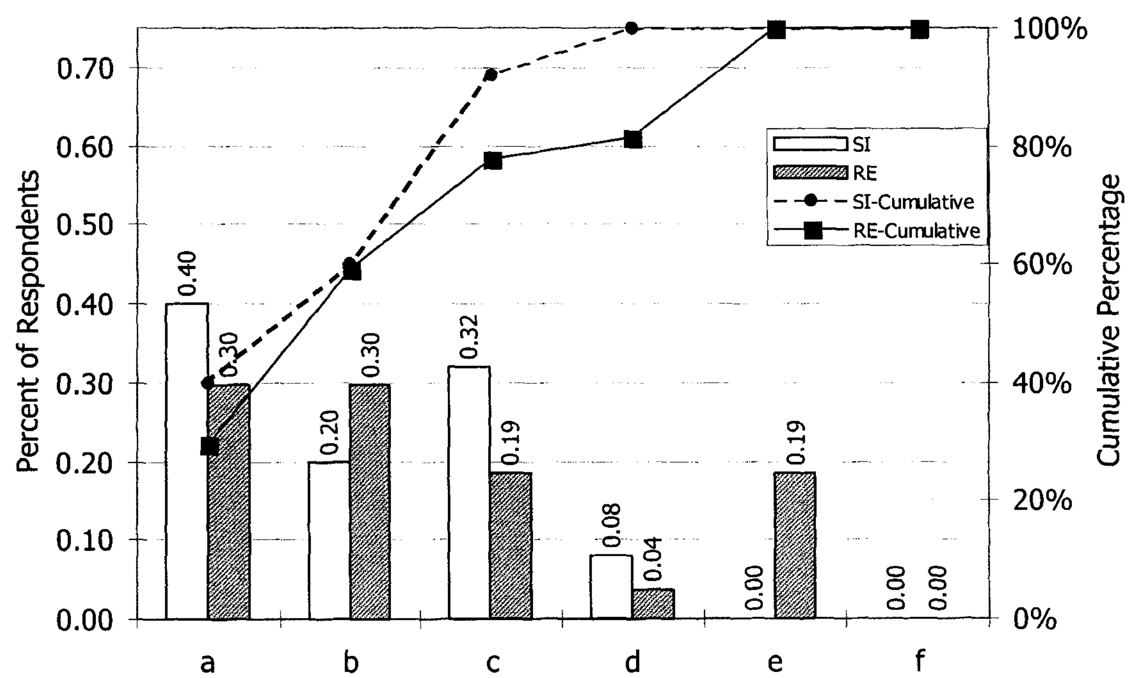


(a) Bar charts
(b) CPM
(c) CPM with time-cost trade-off analysis
(d) CPM with resource allocation
(e) Repetitive scheduling technique
(f) Computerized material inventory and flow control
(g) Computerized equipment management
(h) Computerized information flow and feedback system
(i) Don't know
(j) Other (please specify)

FIG. 7. Contractors' Managerial Practices



(a) Special considerations in selecting subcontractors
(b) Special considerations in appointing senior project personnel
(c) Special considerations in selecting field personnel
(d) Using outside consultants
(e) Don't know
(f) Other

FIG. 8. Contractors' Personnel Policy

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projects, and ample availability of critical resources. In contrast, few contractors adopted special considerations in selecting field personnel (32%) and senior project personnel (20%), and only 8% used outside consultants. The Spearman rank correlation coefficient of 0.714 indicates that REs and SIs do not agree on their perceptions of the personnel and manpower policy adopted by the contractors to achieve the I/D targets.

The incentive payment received is passed down to the middle and/or upper management level by 70% of the contractors (question 19). Workers do not directly receive a share from the incentive; rather, they benefit from the bonus in terms of overtime payments. Probably because this is an internal matter concerning the contracting organization, the majority of the REs (78%) indicated that they did not know the answer to this question. This line of thought may also explain the relatively large negative r_s value of -0.575 (Table 1).

Comparison of I/D versus Non-I/D Contracts

All the SIs questioned in the survey claimed that they had expedited their projects to the fullest extent possible under the given circumstances (question 20). An interesting finding of the survey was that 100% of the contractors agreed that the associated I/D projects would have taken longer to complete by an average of 21% per project had these contracts not included I/D provisions. Over half of the REs (56%) agreed with the contractors on this issue. However, they expected that these projects would last on average 44% longer if they were non-I/D projects. Only 6% of the REs thought that non-I/D projects would take less time to complete than comparable I/D projects, implying that there exist rare cases where the inclusion of I/D provisions is redundant. The remaining REs (39%) did not know the answer to this question.

Assuming the daily I/D amount is constant, respondents were asked in question 21 whether it would be possible to complete an I/D project earlier than the specified target, i.e., beyond the time saving that corresponds to a maximum incentive. Fifty-five percent of the contractors, as opposed to 19% of the REs, expected time savings that could exceed the allowable cap specified in I/D contracts by an average of 15 days (contractors) and 4 days (REs). The REs' perceptions seem to be on the conservative side on this issue. Given the potential for further time savings as indicated especially by contractors, it should be possible to realize even earlier project completion in I/D contracts.

Initially it was believed that non-I/D contracts would typically receive lower bids than similar I/D contracts, the main reason being that I/D contracts are accelerated and involve greater risks including substantial penalties in case the project is delayed. It was indeed shown in an earlier study (Arditi et al. 1997) that non-I/D contracts were bid on average lower than I/D contracts with similar contract value and scope of work. However, only 18% of the contractors and 44% of REs agreed with the finding that projects bids would be lower for non-I/D projects (question 10). In contrast, 82% of the contractors but only 6% of the REs expected higher bids had this been the case. Apparently, most contractors tend not to accept the fact that they would have bid lower if the contract did not include I/D provisions, even though this is the reality in day-to-day practice. It appears that the risk transfer associated with I/D contracts is perceived by contractors to be high enough to force them to inflate their bids as a cushion against the possibility of increased costs that could be incurred due to the acceleration involved in such projects.

I/D Contract Changes

The perceptions of the parties regarding the frequency (question 4) and magnitude (question 5) of change orders are mainly in agreement (Spearman rank correlations of 1.00 and 0.75, respectively) but do not concur with reality. Almost half of the respondents stated that the frequency (45% of SIs and 50% of REs) and magnitude (36% of SIs and 50% of REs) of change orders in I/D contracts were the same as in non-I/D contracts, whereas few respondents thought that change orders occurred more frequently (18% of SIs and 11% of REs) and had a greater dollar value (9% of SIs and 19% of REs) than in non-I/D contracts. However, an earlier study shows that the frequency and magnitude of change orders in I/D contracts are in fact larger than the ones in non-I/D contracts (Arditi et al. 1997). The large number of respondents that did not know the answer to these two questions (36% of SIs and 33% of REs to question 4 and 36% of SIs and 25% of REs to question 5) is also an indication that both contractors and IDOT personnel are misinformed regarding the impact of change orders on their management of I/D contracts.

I/D Implementation Problems

The last question of the questionnaire asked the respondents to note the most critical problems encountered in I/D contract applications that normally would not be encountered in non-I/D contracts and to add their comments on I/D provisions. The problems mentioned by REs and SIs regarding the use of I/D contracts include scheduling difficulties, contract language interpretation, crew redundancy affecting productivity, working in adverse weather conditions to maintain the schedule, disputes over what constitutes clean-up and punch-list items, adversarial relationships within the contractor's team resulting from the pressure of trying to achieve the maximum incentive, traffic staging (in particular, ramp closures and openings), extreme volumes of work to finish in the last month prior to full bonus, delays in the timely review of shop drawings and change order approval, shorter decision-making processes made more difficult by a related shorter list of alternatives to choose from, and sacrificing quality for speed. These issues do not constitute universal findings and, as such, have to be treated with reservation. However, they may be helpful in understanding I/D contracting better and in refining its implementation. They may also be consulted when planning for I/D provision to help decrease the amount of conflicts during the project's lifetime.

CONCLUSIONS AND RECOMMENDATIONS

The intent of this study was to identify the perceptions of REs and SIs regarding the use of I/D provisions in IDOT contracts. The current process of establishing I/D targets by IDOT, the implementation of I/D provisions in contracts, novelties and specific procedures associated with the implementation of I/D contracts, and the evaluation of contractors' performance by IDOT were investigated.

The major findings of the study indicate that there is a statistically significant agreement in REs' and SIs' perceptions regarding a number of critical issues, such as the calculation of project duration, the definition of "completion of the project," the importance of certain project objectives, the type of expedited work schedules used by contractors, and the frequency and magnitude of change orders in I/D contracts. On the other hand, REs and SIs seem to disagree on the project stage at which I/D provisions are included, the nature of difficulties contractors face during I/D implementation, the general measures taken, the technical and/or managerial improvements introduced, the personnel/manpower policies adopted by contractors to fulfill I/D targets, and whether bids would be lower for non-I/D contracts as opposed to I/D contracts. It should be noted that the results of the survey are not all-conclusive due to the limited size of the sample. Nevertheless, the

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findings are statistically significant to validate the conclusions drawn.

To resolve the current problems associated with I/D contracts that were identified through the course of this study and to enable more cost-effective implementation of I/D provisions in contracts, the following measures are recommended.

- Contractors are sometimes not knowledgeable enough about why owners use I/D contracts and how these contracts are implemented. For example, they are not always conscious of how I/D provisions are set, at which stage of the project they are introduced, that change orders occur more frequently and have higher dollar values than in non-I/D contracts, and that I/D contracts normally attract higher bids than comparable non-I/D contracts. Increasing contractors' awareness of the objectives and the processes of I/D contracts may improve I/D contract implementation.
- REs are not always cognizant of the practices that contractors have developed to deal with the requirements of I/D provisions. Contractor-related issues such as labor problems generated by longer working hours and multiple shifts, the tendency to use extreme measures towards the end of the project rather than using technological and managerial advances throughout the project, the use of CPM to control the project but the use of bar-charts to report progress, and the necessity to develop special requirements when negotiating with subcontractors are not readily recognized by REs. The construction owner's better understanding of the implications of I/D clauses on contractor practices may also improve I/D contract implementation.
- A critical issue in successfully applying schedule incentives/disincentives is the accurate determination of the project duration by the owner. As recommended by Fisher (1969), realistic and tighter target costs should be established for cost-incentive contracts to be motivational. Similarly, in "incentive-incited" projects, incentives will not result in savings unless the schedule target is realistically established. Therefore, especially in I/D contracts, a standard computerized CPM procedure should be established to determine project duration. This will eliminate the risks of paying extra monies for a contract that has a loose schedule in the first place. This will also enhance the owner's project control. IDOT's traditional methods, i.e., bar-charts drawn using standard daily production rates, past experience on similar projects, and rules of thumb, do not hold up against the sophisticated project-management techniques that are probably used by most contractors.
- The increased frequency and magnitude of change orders in I/D contracts cost time and money, and yet both SIs and REs are under the false impression that change orders are as frequent and as large as in non-I/D contracts. Plans should be developed to identify the change orders as early as possible and to minimize their occurrence and impact on project duration and cost. These plans could include better definition of the scope of work, better coordination between the owner and the contractor, and reducing the processing time of change orders.
- The contractors surveyed in the study have stated that the I/D projects they undertook could have been further expedited had the incentive duration been longer. Increasing the number of incentive days without exceeding the 5% limit might shorten project duration without increasing total incentive. Combined incentives of cost and schedule can be used on an experimental basis to achieve cost and time effectiveness in a project. The contractor is always interested in increased profit, so the profit-sharing formulas provided in the text can be used depending on the scope of the work. It should be remembered that cost savings do not necessarily accompany early completion, so additional incentives might be necessary to achieve construction cost effectiveness. Keeping the 5% I/D cap on the contract amount, the number of incentive days can be calculated in a reverse fashion by dividing the total available incentive amount (0.05 × contract amount) by the road user delay cost.
- The use of "A + B Bidding" in association with I/D contracts should be explored further. "A + B Bidding" is an effective method in selecting a contractor, because not only contract costs but also project durations are proposed by the bidders on a competitive basis. It is likely that the contract duration set by the winning bidder will be more realistic compared to the contract duration set by the owner in I/D contracts. "A + B Bidding" is expected to eliminate the selection of inefficient contractors. Further research is recommended to lay down the principles of implementing "A + B Bidding" and to evaluate the likely impact of such implementation on contract efficiency.

Incentives/disincentives are effective and efficient contract management tools, unless applied redundantly. It is crucial to make sure that the project will absolutely benefit from I/D in terms of both time and cost. The rate of success in any I/D implementation depends largely on abandoning the use of simple bar-charts based on daily production rates and moving to a state-of-the-art computerized system that allows a realistic estimation of project duration and an effective control of project progress. The design and adoption of such a system is a prerequisite to any experimentation with any of the aforementioned recommendations regarding I/D contracts.

APPENDIX I. QUESTIONNAIRE

Illinois Institute of Technology Department of Civil and Architectural Engineering Questionnaire on I/D Provisions and their Implementation

1. How is project duration established by IDOT prior to the commencement of the I/D project?
   (a) Based on similar projects
   (b) Based on an analytical model developed for this purpose
   (c) With informal input from contractor
   (d) After formal negotiation with the contractor
   (e) Don't know
   (f) Other (please specify)

2. Why was this project chosen as an I/D project? Please mark as many as appropriate.
   (a) High visibility project
   (b) High volume road
   (c) High road user delay cost
   (d) Severe disruption on adjacent businesses
   (e) Project with direct bearing on project start and/or interruption of progress on major freeways, arterials, or structure
   (f) Project involved with major reconstruction of an existing highway
   (g) Project with benefits, in terms of cost savings and/or safety, that outweight the cost of incentive payments and additional construction costs
   (h) A part of a contract that can be done well before the rest of the work and is of significant benefit to the public (e.g., early use of a highway lane)

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(i) Project was a prerequisite to the use of some other projects (e.g., filling a gap or removing a serious bottleneck)
(j) Project was needed by a specific date to provide service to some other traffic generator (e.g., a new school)
(k) Project involved the prolonged closure of one or more highway lanes
(l) River structure in or adjacent to central business district
(m) Night-time construction on major urban freeway
(n) Part of a cooperative I/D project application
(o) Don't know
(p) Other (please specify)

3. At what stage were I/D provisions included in the contract?

(a) At the planning stage
(b) At the design stage
(c) At the bidding stage
(d) At the construction stage
(e) Don't know
(f) Other (please specify)

4. What was the frequency of change orders in this project compared with an average non-I/D project?

(a) As frequent as in an average non-I/D project
(b) More frequent than in an average non-I/D project
(c) Less frequent than in an average non-I/D project
(d) Don't know

5. What was the magnitude of change orders compared to an average non-I/D project?

(a) As big as in an average non-I/D project
(b) Bigger than in an average non-I/D project
(c) Less than in an average non-I/D project
(d) Don't know

6. Rank the following objectives targeted in this contract in order of importance (1 for most important, 6 for least important).

( ) Schedule
( ) Safety
( ) Cost
( ) Technology
( ) Quality
( ) Management

7. How are the lines of communication between IDOT and the contractor developed?

(a) By predesign field reviews
(b) By preconstruction meetings
(c) By regular construction meetings
(d) Informal communications
(e) Other (please specify)

8. Were the I/D provisions negotiated in these meetings and/or communications?

(a) Yes
(b) No
(c) Don't know

9. Were any disputes caused by objections raised by the contractor to I/D provisions?

(a) Yes
(b) No
(c) Don't know

10. Would bids in this project be uniformly lower if the project were a non-I/D project?

(a) Yes, substantially
(b) Yes, marginally
(c) No
(d) Don't know

11. What was the criterion used to define the completion of the project?

(a) Unrestricted traffic is permitted (clean-up and demobilization included)
(b) Unrestricted traffic is permitted (clean-up and demobilization not included)
(c) Substantial completion (inconsequential portions missing or minor repairs necessary)
(d) Don't know
(e) Other (please specify)

12. Did the contractor's expedited work schedule involve one of the following schemes? Please mark as many as appropriate.

(a) Six day work week
(b) Seven day work week
(c) Double shift
(d) Triple shift
(e) Extended work hours with 12–14 hours per day
(f) Expedited work schedule with 228 working days per calendar year
(g) Multiple work crews in multiple areas
(h) Other (please specify)

13. Did the contractor experience difficulties in the following due to labor agreements?

(a) Optimizing crew sizes
(b) Adjusting scheduled overtime
(c) Setting wages in second or third shifts
(d) Increasing labor productivity
(e) Don't know
(f) Other (please specify)

14. What measures did the contractor take to fulfill the I/D targets?

(a) Planned technological/managerial novelties
(b) Ad hoc measures as necessary
(c) Extreme compression of activities towards the end of the project
(d) Don't know
(e) Other (please specify)

15. If technological/managerial improvements were introduced, which category do they belong to?

(a) Advanced construction methods
(b) Advanced equipment
(c) Advanced materials
(d) Advanced construction management techniques
(e) Don't know
(f) Other (please specify)

16. What managerial practices were used by the contractor to fulfill the I/D targets? Please mark as many as appropriate.

(a) Bar charts
(b) CPM
(c) CPM with time-cost trade-off analysis
(d) CPM with resource allocation
(e) Repetitive scheduling technique
(f) Computerized material inventory and flow control
(g) Computerized equipment management

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(h) Computerized information flow and feedback system
(i) Don't know
(j) Other (please specify)

17. What special personnel and manpower policy was adopted by the contractor to fulfill the I/D targets?

(a) Special considerations in selecting subcontractors
(b) Special considerations in appointing senior project personnel
(c) Special considerations in selecting field personnel
(d) Using outside consultants
(e) Don't know
(f) Other

18. How is the incentive amount paid to the contractor?

(a) In full upon completion of some milestone activities
(b) Partially upon completion of some milestone activities
(c) In full upon completion of the project
(d) Other (please specify)

19. Does the contractor pass the incentive down to its personnel? If yes, down to what level?

(a) Yes, down to upper management
(b) Yes, down to middle management
(c) Yes, down to workers
(d) No
(e) Don't know

20. Would the project last longer if it were a non-I/D project?

(a) Yes, by __%
(b) No
(c) Don't know

22. What were the critical problems encountered in this project that would not be seen in an average non-I/D project?

Thank you for spending the time to fill in this questionnaire. Any additional comment that you think might be helpful in this research on I/D contracts would be appreciated. Please use the space provided below for your comments.

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