Integrated Modern Contract Management for Highway Construction Work in Lebanon

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After years of war, the deteriorated road network in Lebanon is in urgent need of rehabilitation and reconstruction. Previous projects have been characterized by budget overruns, poor quality, untimely completion, and disputes. This, along with the limited availability of public funds, raises the need to focus on the efficient execution of future projects to be administered by the Directorate of Roads of the Ministry of Public Works. In this research, modern and innovative concepts of contract management have been explored with the objective of improving current practices. Concepts considered include a comprehensive prequalification process, a multiparameter approach for bidding, surety bonding, night-time construction work schedules statistically based end-result specifications, adjusted pay schedules, owner-furnished equipment, prepayment and escalation clauses, and arbitration for dispute resolution. An integrated contract management approach is presented that is directed toward understanding the interactions, interrelationships, and interdependencies that exist among candidate concepts and strategies. Any attempt to deal with one contract aspect independently of the others may prove to be of little use. The integrated approach is expected to aid in (a) ensuring project success with regard to cost, schedule, quality, and safety and (b) enhancing competition and technology diffusion, while reducing disputes and contractor risks and financial obligations.

Roads in Lebanon have suffered extensive damage during 17 years of civil war, while receiving minimal maintenance and rehabilitation work. There are a total of about 3270 km (about 2000 mi) of roads in the network, 2000 km (about 1250 mi) of which have various levels of distress requiring some form of maintenance, rehabilitation, or reconstruction. The rehabilitation program for the roads network has been drawn up for execution in 5 years, with a preliminary funding requirement equivalent to more than 350 million U.S. dollars.

Despite the urgent need for implementing highway projects, the Directorate of Roads (DR) of the Lebanese Ministry of Public Works is constrained by the limited availability of public funds, from internal and external sources. This, in turn, raises the need to focus on the efficient delivery of future projects, especially because high cost, poor quality, and untimely completion have been common characteristics of previous projects.

RESEARCH OBJECTIVES

The objective is to seek and explore modern and innovative contract management practices that will ensure the most effective implementation of highway projects. Candidate areas include the prequalification process, bonds and insurance coverage, bidding policies and strategies, specifications and quality control methods, scheduling and delay problems, traffic congestion and night-time construction, safety, inflation and payment procedures, and claims and dispute resolution procedures. The ultimate objective is to provide an integrated approach, aimed at investigating and defining the interactions and interrelationships among all contract management areas studied.

The methodology used in this work involved: (a) review of current contract management practices through careful examination of the adopted construction documents (*1*), (b) interviews with a number of DR officials and prequalified highway contractors to document the major problems that they have encountered, (c) search of the technical literature for modern and innovative contract management concepts, and (d) manipulation and assimilation of the collected information into an integrated approach for implementing potential improvements.

FACTORS AFFECTING CONSTRUCTION CONTRACT

Figure 1 illustrates the factors thought to lead to the unsuccessful completion of highway projects. In view of the inherent risks, contractors incorporate varying contingency amounts in their bid prices. These contingency amounts depend on the types of risk anticipated, contractor attitude towards risks, and the level of accuracy in contractors' risk quantification (*2*). With limited financial capabilities, some contractors tend to allocate high contingency amounts, resulting in inflated bid prices. On the other hand, their need for work coupled with high competition may cause other contractors to use low contingency amounts to improve their chances of winning contracts (*3*). Such unrealistically estimated low bids may result in an increased number of disputes and, eventually, in total project costs that are higher than those of the most reasonably estimated bids.

SYSTEM WEAKNESSES AND POTENTIAL IMPROVEMENTS

This section deals with major aspects of contract management. For each aspect, the weaknesses of current practices are first identified, and potential improvements are suggested that incorporate innovative management concepts and practices.

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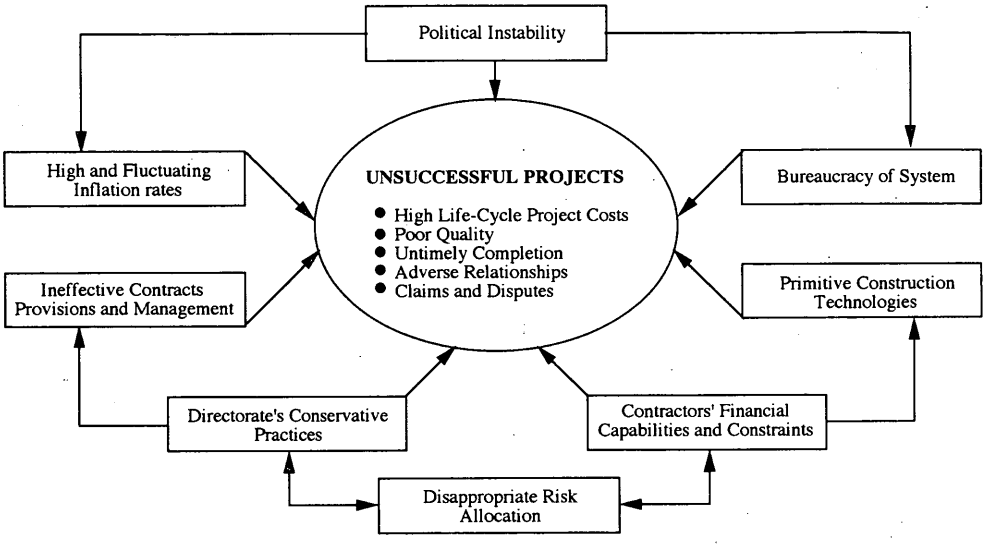

FIGURE 1 Factors leading to unsuccessful projects.

Prequalification of Contractors

Current Process

As indicated by interviewed DR officials, the current prequalification system tends to focus only on certain aspects involving the financial capabilities of contractors, the experience of the contractor's engineer, and the number and types of construction equipment owned. The system almost completely ignores other important aspects including the contractor's organizational framework, quality control systems, computer-based scheduling techniques, and safety programs. The process also limits to three the maximum number of uncompleted contracts a contractor may hold concurrently, without any consideration of individual specific qualifications and capabilities.

Systematic Approach

A more comprehensive and systematic process is needed that would evaluate all aspects of a contractor's qualifications (*4*). Under such an approach, an aggregate weighted rating is calculated for each contractor, which is then compared with an established minimum aggregate threshold. To overcome the shortcoming of a high rating in one factor compensating for a low rating in another, a minimum allowable rating for each factor may be specified. In the case of projects that require special qualifications relevant to one or more of the variables in the prequalification system, minimum allowable ratings specific to these project variables can be set. The ratings of a contractor's capabilities can also be used for determining the volume of work the contractor can undertake concurrently.

Bond Coverage

Bonding Requirements

Bid proposals must be accompanied by bid bonds in the amount of 3 percent of bid prices. A performance bond for 10 percent of the contract price must be submitted by the successful bidder within 10 days of the date of confirmation of the contract price by the Accounting Hall (*1*). This bond could be in the form of a cash deposit or a bank letter of credit. To obtain a letter of credit from a bank for 10 percent of the contract price, a contractor may have to freeze as much as one-and-a-half times that amount. Such a requirement sometimes hinders small contracting firms from tendering bids, thus reducing competition. This is because the number and amount of credit lines that a contractor could obtain from banks are greatly reduced by the amount of issued guarantees, because these are viewed by banks as contingent liabilities (*5*). Even if banks agree to finance both, it would be at higher premiums. The disadvantages resulting from the emphasis on financial bonds are illustrated in Figure 2.

Recommended Actions

The current bonding requirements often result in an adverse relationship between the DR and contractors, which may be detrimental to project success. Short- and long-term actions are recommended to provide adequate protection to the DR and, at the same time, reduce the financial burden and risk imposed on contractors. The short-term actions include (a) acceptance of collaterals as guarantees, (b) adjustment in bond amounts as work progresses, and (c) bond forfeiture on an arbitrator's statement. In the long run, surety bonds are highly recommended as opposed to financial bonds issued by banks. However, surety bonds are not available in Lebanon, and as shown in Figure 3, many obstacles exist to their availability in the near future.

Bidding System

Current Practices

Construction contracts are awarded on a competitive bidding basis in which contractors are required to complete the project within a maximum specified duration. Two systems prevail.

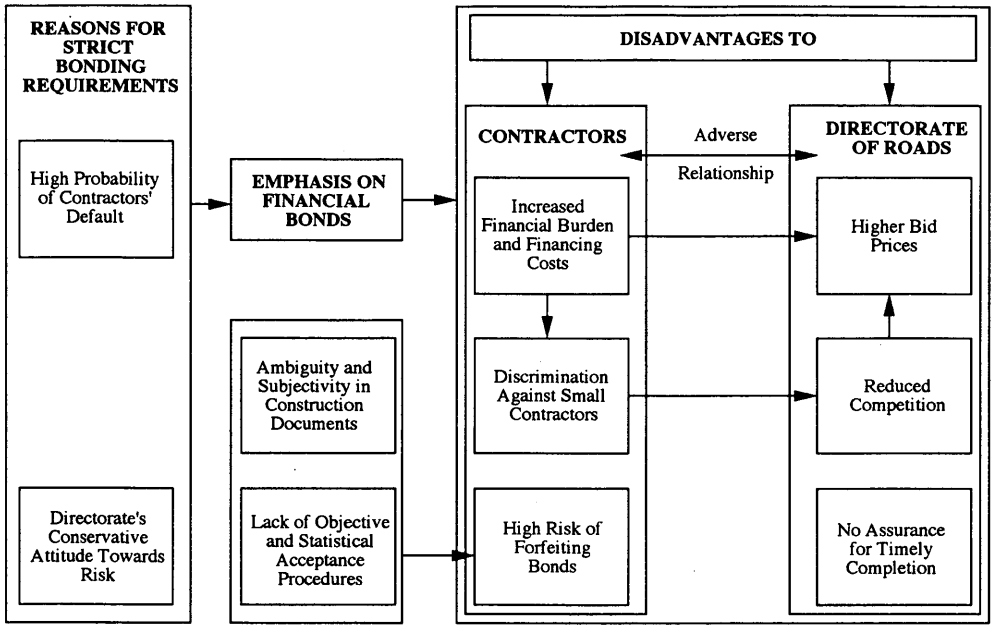

FIGURE 2 Overview of current bonding practices.

1. *Open competitive bidding:* All interested, prequalified contractors are given the opportunity to participate in the bid-tendering process.
2. *Competitive bidding by invitation:* The DR invites selected contractors with certain qualifications and experience to bid on projects. This system is more often used, particularly for urgent projects. However, the interviewed contractors reported that the selection is based on the judgment of DR officials, thus giving room for favoritism, bias, and corruption.

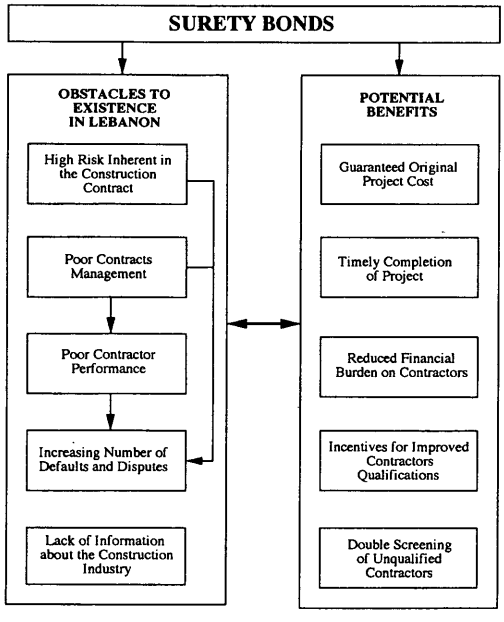

FIGURE 3 Surety bonds: obstacles to existence versus benefits.

As shown in Figure 4, the system adopted has resulted in many adverse effects on the highway construction industry in terms of higher costs, poor quality, untimely completion of projects, and reduced technology diffusion. Such a one-parameter (cost) system does not offer an incentive to contractors to shorten the projects and improve the quality of work by adopting innovative equipment and technologies and proven construction management techniques.

Multiparameter Approach

The multiparameter bidding system (*6–8*), which functions within the framework of the competitive bidding concept, may provide significant advantages over the current bidding system. The system is based on the concept that the successful bidder will be selected based on the cost, time, and quality offered by the bid.

Contract awards would then be made on the basis of the lowest total equivalent cost (TEC) calculated from a combination of bid price (BP) and schedule- and quality-equivalent cost figures. The schedule-equivalent cost (SEC) figure might be determined by multiplying a proposed duration by a predetermined time-equivalent rate, which could be set equal to the daily rate of stipulated liquidated damages. The quality-equivalent cost figure could be quantified on the basis of future performance reflecting the notion that better quality, although it entails a higher initial price, reduces project life-cycle costs (*8*). The future performance approach would allow contractors to bid on quality the same way they bid on cost and time. For instance, a contractor might propose in a bid a final mix density of 98 percent, compared with specified average density of 95 percent. This higher density would involve closely monitoring the compacting operations, which would result in increased construction costs. However, a higher achieved density would reduce future maintenance costs and increase the life span of projects. Therefore, the quality-equivalent cost (QEC) figure could be thought of as the present value of the expected

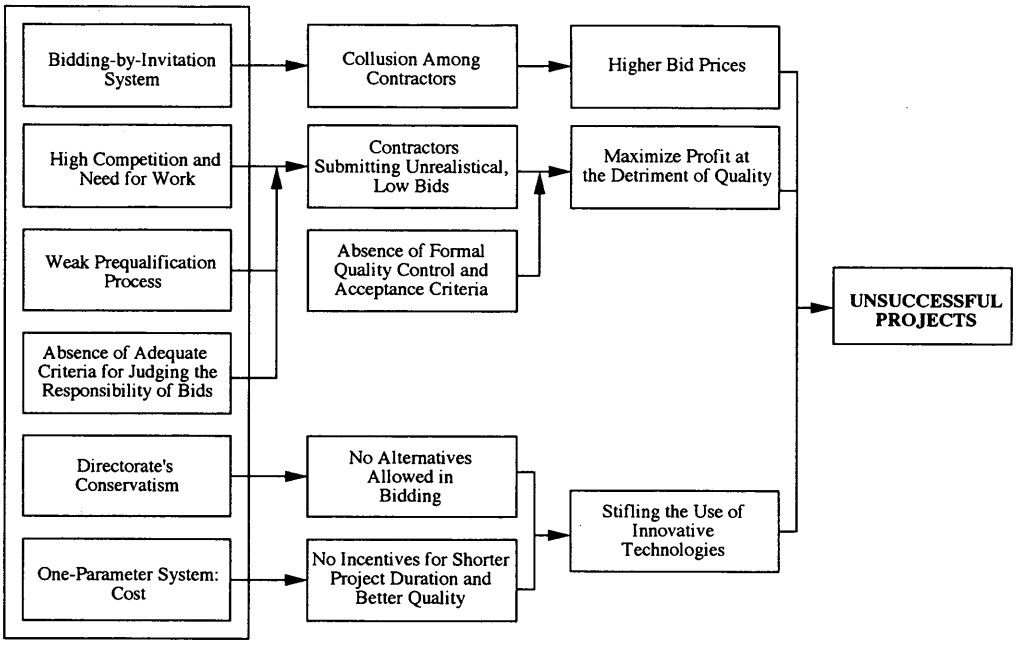

FIGURE 4 Weaknesses of current bidding practices.

annual maintenance expense associated with the specified density range or a higher proposed density spread over the corresponding project life span. Then, the total equivalent cost could theoretically be expressed as

$$TEC = w_1(BP) + w_2(SEC) + w_3(QEC)$$

where w_1, w_2, and w_3 represent percent weights totaling one. This could be used to reflect the judgment of DR about the relative importance of individual cost figures.

In spite of the potential benefits of the multiparameter system, there are prerequisites to be fulfilled before such benefits may be realized. These are illustrated in Figure 5.

Specifications and QA/QC Programs

Prevailing Deficiencies

One deficiency of the contract management system is in the unstructured organization of the construction documents, particularly specifications, thus causing difficulties to contractors in locating necessary information. In addition, specifications are mostly descriptive, with almost no opportunity for contractors to consider or explore innovative materials and technologies. Moreover, the evaluation of accomplished work for acceptance and the determination of an applicable penalty for inferior work quality are based solely on the arbitrary judgment of DR engineers, and phrases such as "to the satisfaction of the engineer" or "to a reasonable quality" are not uncommon. Finally, major contractors reported that design plans, in addition to being conventional, generally fail to reflect existing site conditions; the contractors are held responsible for any design deficiency that may escape their review.

Modern Practices

It is recommended that the DR adopt a systematic approach for producing better standardized construction documents and specifications, thus helping reduce the liability and risk exposure of both parties (*9*). By providing a properly reviewed and managed design, the construction of a project would cost less and disagreements and subsequent litigation would be minimized (*10*). The DR is also urged to conduct value engineering analyses to select the most feasible designs, with consideration given to the life-cycle cost of projects instead of to the initial cost solely (*11*).

End-result specifications would give contractors the opportunity to select a method of construction that best helps them meet the performance requirements specified. In this regard, the DR is also urged to adopt formal acceptance criteria, to recognize the inherent variability in the quality of completed work, and to deal with such variability in a realistic manner. Statistically based specifications with adjusted unit prices would provide the solution (*12*). With such a system, price adjustment factors are based on the weighted means and standard deviations of quality parameters such as achieved mix density as measured by reliable tests. A price adjustment schedule would include, for example, a price reduction to be applied for deficient work and a bonus for better-than-specified work (*13*). Nevertheless, an option to require removal and replacement of unacceptable work at the expense of the contractor would still be included. A vital concern in the development of adjusted pay schedules is the determination of appropriate pay levels for various levels of quality. Such a schedule would be designed to withhold sufficient payment at the time of construction to cover the cost of future repairs made necessary by defective work.

Formal sampling procedures and test methods should be adopted or developed to cope properly with statistically based specifications. Emphasis should be placed on the use of nondestructive testing in the monitoring of construction work quality (*14,15*).

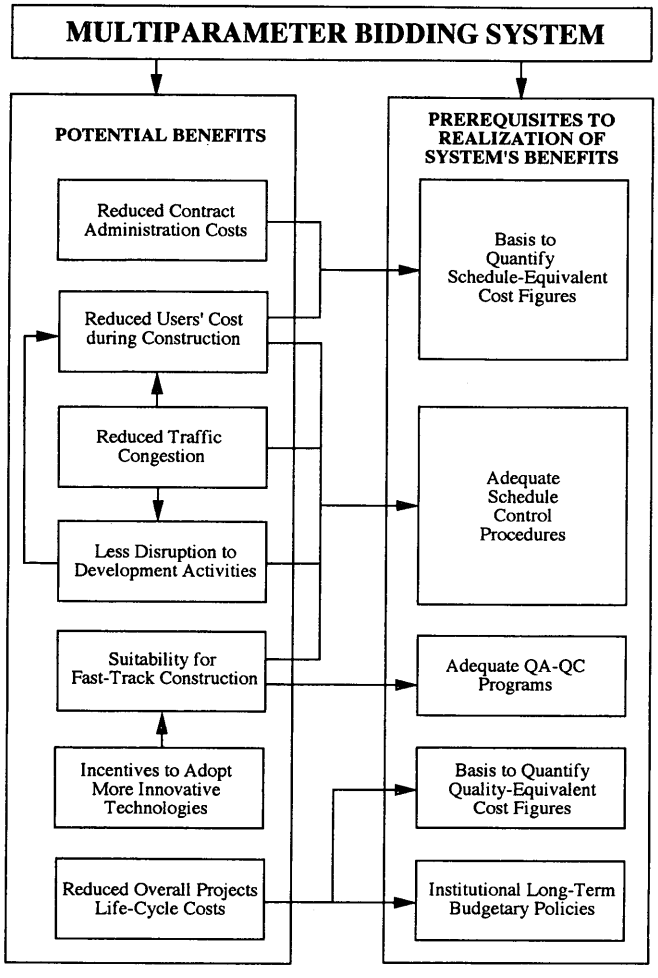

FIGURE 5 Prerequisites to realization of potential benefits of multiparameter bidding system.

Owner-Furnished Equipment

A contract management technique that should be contemplated for urgent rehabilitation projects is based on the concept that the owner may choose to furnish innovative and more productive equipment for use by contractors, particularly when such equipment is more expensive than individual contractors can afford. By adopting this concept, the DR would hedge the cost of equipment ownership against inflation and would reduce contractor financial obligations, ultimately resulting in lower bid prices. In addition, innovative equipment may result in a substantial increase in productivity that would, in turn, yield shorter schedules and cost savings (*16*).

Schedule Control Procedures

Because of institutional and political implications, little schedule control has been practiced with the exception of a rare enforcement of the liquidated damages provisions. The DR is therefore urged to use, and to require contractors to use, effective scheduling techniques to determine contract duration and to monitor and control the execution of projects. Such techniques may include the critical path method, line of balance method for linear scheduling, computer simulation of repetitive construction cycles, or a combination of these methods (*17*).

The recommended techniques should provide an objective basis for determining the necessary amount of time extensions for excusable delays instead of the subjective opinions of DR officials. Other recommended actions with the potential benefits and anticipated obstacles are shown in Figure 6.

Traffic Congestion and Night-Time Construction

Night-time construction has rarely been considered, except on a few urgent projects. However, with the severe traffic congestion experienced on most highways in Lebanon, the DR should study the feasibility of allowing night-time construction by investigating all the factors pertaining to such a decision, including highway class, anticipated level of congestion and travel delay due to the execution of work, existence of a feasible detour route, and road user cost. Where problems exist, night-time work schedules should be desirable and, therefore, be encouraged or required as part of the contract. Because of the lack of recent and complete statistics concerning the transportation sector, decisions might be based on limited traffic volume counts and queuing theory analysis, as well as on the experience and

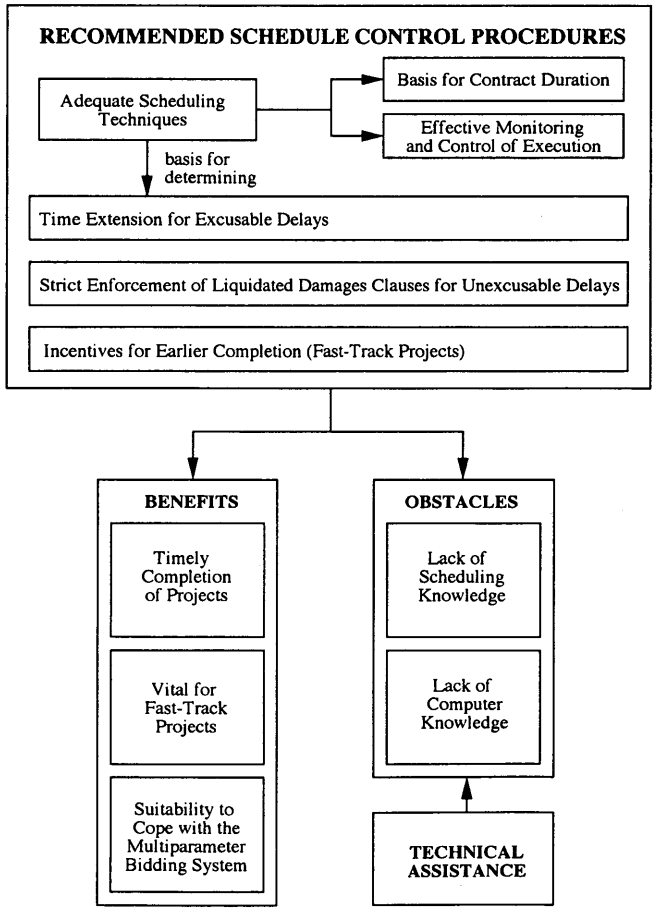

FIGURE 6 Recommended schedule control procedures: potential benefits and obstacles.

judgment of qualified DR officials. Figure 7 gives the potential benefits of night-time construction and associated limitations (*18*).

Safety Control Measures

The DR and highway contractors have failed to recognize that an effective safety program can reduce the added direct and indirect accident costs to projects. This is unfortunate because the ratio of hidden costs to direct costs can be as much as four to one or higher (*19*). In view of prevailing attitudes towards safety, the DR and contractors are urged to regard money spent on safety programs as investments and not as cost elements because a 4- to 8-dollar return can be expected for each dollar invested in safety (*20*). The following comprehensive and effective safety programs should, therefore, be developed.

- The DR should make the contractor's safety record an essential element of the prequalification process.
- The DR should develop methods of accountability and establish clear and systematic procedures for recording events and problems encountered on construction sites.
- The DR should set standards for safety measures and performance for shoes, hats, gloves, fences, adequate lighting, alarming devices, and traffic control devices.
- The DR should oblige contractors to furnish proof of insurance coverage, as an incentive to improve safety performance because insurance premiums depend primarily on the contractor's safety record (*21*).

Progress Payment and Inflation

Current Payment Procedures

Unit prices, all in Lebanese pounds, constitute the basis for payment to contractors. Progress payments are made monthly as approved by DR engineers, on the basis of their determination by field measurement of the actual quantities of work satisfactorily performed during the period covered by the payment. Ten percent of each progress payment is retained by the DR until the end of the warranty period.

Financial Risk Exposure

Interviews with prequalified contractors revealed that they experienced a number of financial problems, which can be summarized as follows: (a) high and fluctuating inflation rates, (b) provision of financial bonds and start-up expenses, (c) no reduction in the retained percentage as project progresses and no adjustment of the retained amount made to account for inflation, and (e) payment delays due to bureaucratic procedures. The results have been increased risk exposure, reduced competition, and higher bid prices.

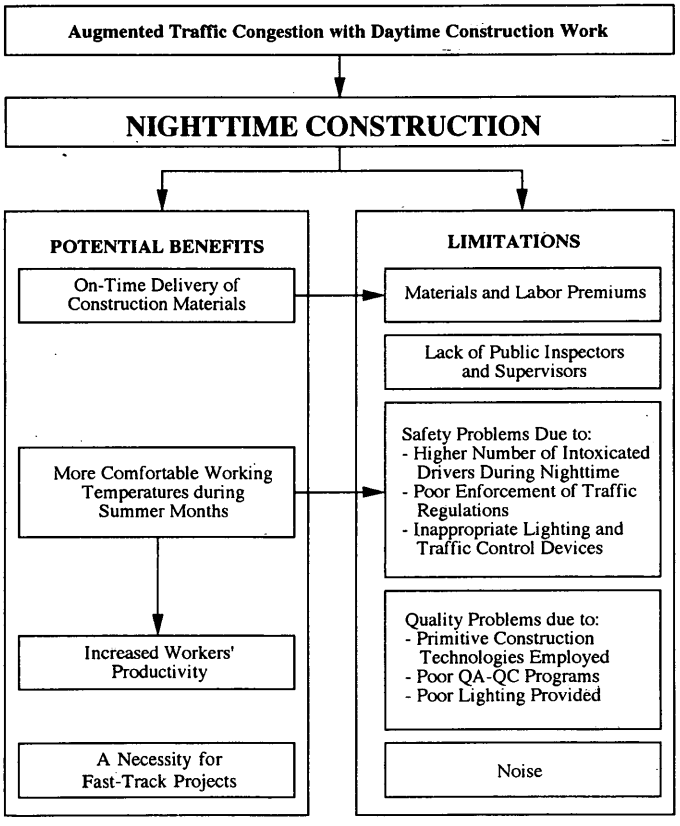

FIGURE 7 Potential benefits and associated limitations of night time construction.

Current Price Adjustment Measures

Inflation in Lebanon has gone beyond control, resulting in substantial fluctuation in the prices of materials, labor, and equipment used in construction. Consequently, inflation has become a major element of risk and uncertainty to the DR and contractors. The current contracts include compensation clauses to adjust prices for the period between the time of bid quotation and the time of work performance. Prices are revised upward or downward in accordance with the following general formula:

$$I = a_0 + a_1(D/D_0) + a_2(EFC/EFC_0) + a_3(MC/MC_0)$$

Where,

I = index reflecting price changes,
D = average exchange rate of U.S. dollar to Lebanese pound for 5 days preceding time of surveying accomplished work,
D_0 = exchange rate of U.S. dollar to Lebanese pound at time of contract award,
EFC = indexed equipment fuel cost for month covered by progress payment,
EFC_0 = indexed equipment fuel cost at time of contract award,
MC = indexed material cost for month covered by progress payment,
MC_0 = indexed material cost at time of contract award, and
a_0, a_1, a_2, and a_3 = relative individual weights for input parameters totaling 1.00.

For the case of asphaltic concrete work, only the costs of diesel and bituminous materials are individually adjusted, with relative weights of 0.25, 0.35, 0.15, and 0.25 assigned to a_0, a_1, a_2, and a_3, respectively. It is therefore assumed that the term D/D_0 would account for changes in the cost of labor, equipment ownership, and other nonbituminous materials. An upward revision is made only for the portion of a price increase that is beyond 5 percent. The final payment is adjusted upward or downward by the portion of the change in the U.S. dollar exchange rate to the Lebanese pound that is beyond 10 percent during the period between the time of certification of completion and that of approval of payment.

The deficiencies of the current compensation clause can be summarized by (a) lumping possible price changes of a number of construction resources in the term D/D_0; (b) not adjusting a sizable portion of the cost (a_0) for inflation, and (c) the inability of the indexes weights to reflect accurately the actual proportions of the different cost elements incurred by contractors. In view of these deficiencies, contractors still include, implicitly, an inflation-risk premium to preserve their profits. On the other hand, the DR has suffered a major difficulty with budget overruns because of excessive price increases.

Optimal Strategy

The optimal strategy to deal with the reported inflationary condition appears to be a combination of prepayment and price escalation clauses; the latter is to be applied only after price levels have increased beyond a predetermined level that can no longer be offset by the prepayment (22). The benefits of prepayment to the DR and highway contractors, along with its possible limitations and potential solutions, are given in Figure 8. Critical to the success of this strategy is the use of adequate indexes and relative weights in the escalation formulas (23). Work is underway to derive such weights statistically for asphaltic concrete work, because these may vary from one project to another, with variables such as the thickness of overlay and the density required. For example, a 10-cm overlay requires double the amount of material needed for a 5-cm overlay, but this does not imply that the required equipment input is doubled for the former to achieve the same final density.

Until surety bonds become available and while contractors are required to furnish financial performance bonds, it is recommended that less emphasis be placed on retainage, because this may entail an increase in bid prices to be eventually borne by the DR. It is therefore suggested that retainage be adjusted downward as the project approaches completion and that contractors be able to substitute other forms of security (such as collaterals) for a portion of the retainage, provided they show adequate performance as judged by statistically based criteria and sampling procedures. Such a practice would provide contractors with the incentives to improve performance and still ensure the DR enough liquidity to correct defective work.

Under inflationary conditions, it is only reasonable that the retained amount be adjusted to retain its value. This adjustment can be based on the change in the exchange rate of the U.S. dollar to the Lebanese pound. Finally, if payment delays are inevitable, contractors should be entitled to an equitable adjustment of the payment amount.

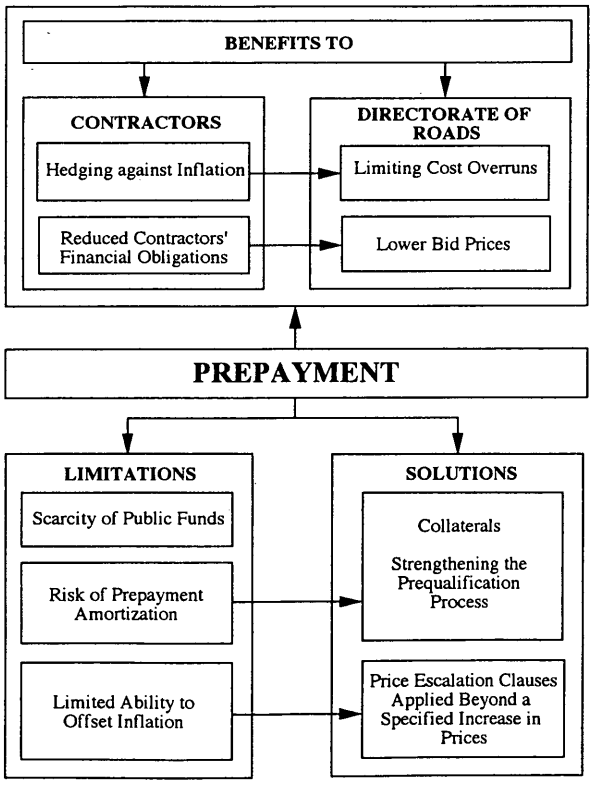

FIGURE 8 Potential benefits and limitations of prepayment.

INTEGRATED CONTRACT MANAGEMENT APPROACH

This section presents a framework for integrating the various contract management areas discussed. The integrated approach may help (a) ensure project success with regard to cost, time, quality, and safety and (b) enhance competition and technology diffusion and reducing disputes and contractor risks and financial obligations. The interactions, interrelationships, and interdependencies among the involved concepts are illustrated in Figure 9 and further discussed as follows:

- A comprehensive and systematic prequalification process would provide the DR with an effective means for screening out unqualified contractors and motivate contractors to improve schedule, quality, and safety control systems and acquire innovative technologies. In addition, strengthening the prequalification process would allow the DR to release its emphasis on financial bonds and retainage. The adjustment of the bond and retainage amounts as work progresses satisfactorily could therefore be contemplated.
- Proper measures concerning bonding and progress payment practices would help reduce contractor financial obligations, which would, in turn, be translated into lower bid prices.
- Innovativeness and technology diffusion can further be encouraged through the following. A multiparameter bidding system that emphasizes schedule and quality performance in addition to cost, thus resulting in earlier completion, better quality, and reduced life-cycle costs of projects; the use of end-result specifications that allow contractors to explore advanced technologies; and the adoption of the owner-furnished equipment concept.
- Improved schedule and quality control systems are essential to cope with the multiparameter bidding system in view of the existing trade-offs among cost, time, and quality. In addition, the use of open competitive bidding as opposed to bidding by invitation, would promote competition, minimize collusion among contractors, and reduce bid prices.
- A bidding system emphasizing quality should be accompanied by statistically based end-result specifications, along with formal and reliable sampling and testing procedures to judge the level of quality achieved. Also, adjusted pay schedules should be designed to account for individual levels of quality to which contractors are committed as part of their bids.
- Obliging contractors to provide insurance coverage will reduce their financial risks in case accidents occur and provide them with incentives to improve their safety programs to keep down premiums.

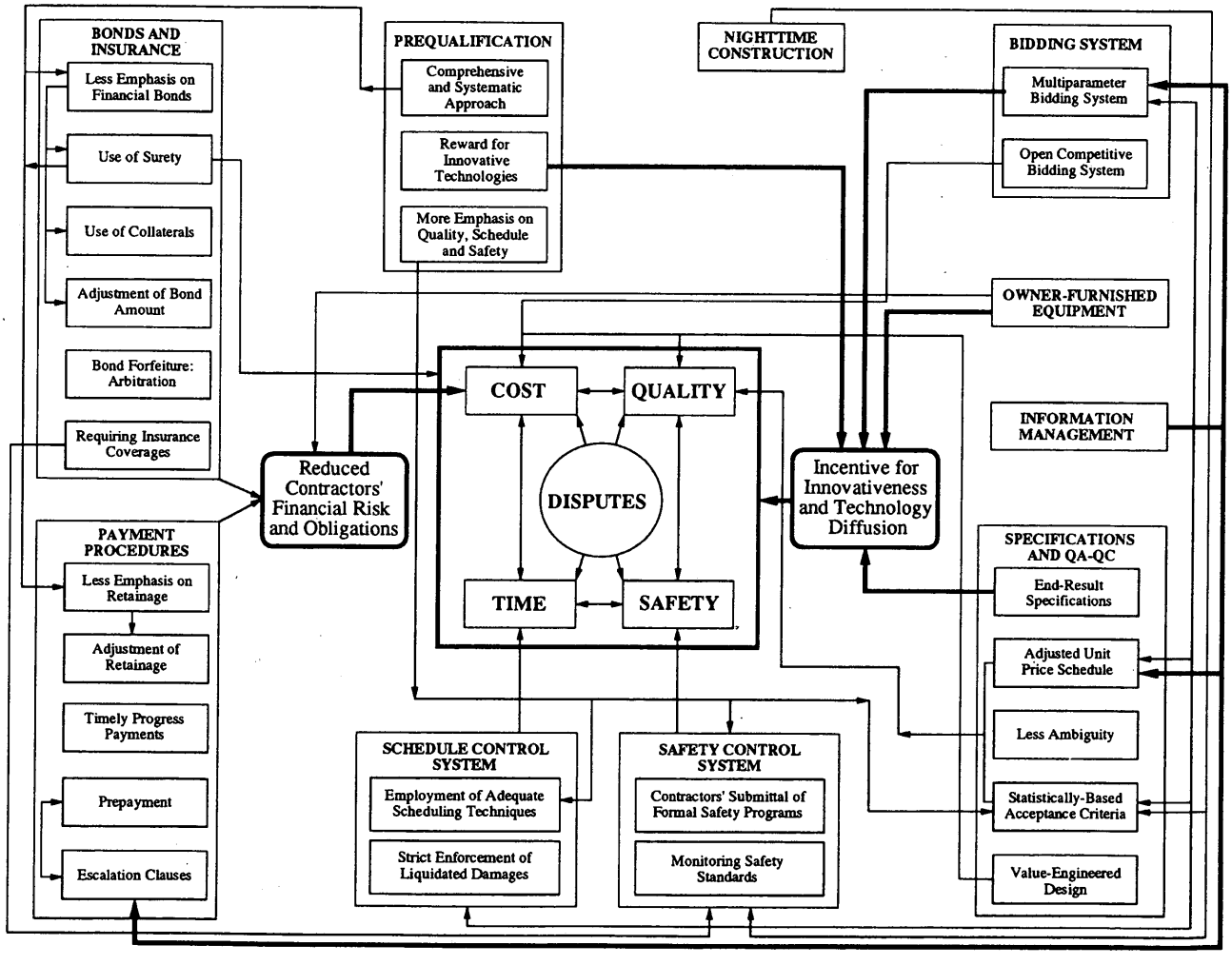

FIGURE 9 Integrated modern contract management system.

- Night-time construction, as a feasible work schedule for fast-track projects, should be accompanied by effective safety and quality control systems to avoid possible accidents and defective work.
- The key to avoiding disputes is the implementation of an adequate contract management system and assignment of competent and qualified personnel to handle claims promptly with a minimum of bureaucratic processing. For inevitable disputes, arbitration should be encouraged to avoid the expenses of litigation and ensure a quick settlement of disputes (*24*). Arbitration is also essential to cope with the problem of bond forfeiture, currently arbitrarily decided by DR engineers in the absence of statistically based acceptance criteria.
- Quantification of schedule- and quality-equivalent cost figures in the multiparameter bidding system, formulation of the escalation clauses, and development of adjusted pay schedules require the handling and manipulation of a large volume of data pertinent to cost, quality, and schedule. Therefore, collection of relevant data and development of adequate data bases and integrated information management systems become of critical importance for the successful implementation of such concepts (*25*).

CONCLUDING REMARKS

Cost, schedule, quality, and safety effectiveness could be improved by structuring the construction contract carefully to reflect clearly project objectives and by allocating risks fairly to both parties. The risk allocation mechanism should ensure optimum assignment of project risks among the parties involved. As such contractors would be held responsible for the controllable risks of meeting contract schedules and quality requirements, whereas the DR would bear the uncontrollable risks such as inflation and adequacy of design. However, this does not imply a complete separation in the risks allocated to each party. Instead, the risk mechanism should emphasize cooperation, reasonableness, and commitment by both parties.

To minimize the impacts of controllable and uncontrollable risks, improvements to the current contracting practices incorporating modern, proven concepts and strategies are warranted. However, special attention must be directed to understanding the interrelationships that may exist among candidate concepts, for any attempt to deal with one aspect independently of the others may prove to be ineffective.

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