AN OVERVIEW OF INCENTIVES AND DISINCENTIVES

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There have been two damaging and well-publicized slurs on the construction industry recently that some may not realize are closely related. About 4 years ago, the Business Roundtable--a collection of Brahmins from the Fortune 500--castigated our industry for high cost, slogging torpor, and terminal malignant ennui. About 2 years ago, the American Society of Civil Engineers--the Brahmins from the ENR 500 reacting to a string of spectacular, grotesque, and unforgivable failures, started to write a "how-to" manual.

They were slurs because--in both cases--the concerned practitioners (buyers in one case, designers in another) stepped outside of and around the construction establishment to find a solution. The Roundtable ignored the Associated General Contractors and founded instead the Construction Industry Institute. The ASCE ignored its own Construction Division and founded a task committee on Quality in the Constructed Project.

These were core entities grown leery. They were related because both found out that both the problem and its solution were rooted in poor management--poor management of costs from business and poor management of risk engineers.

It has been known for 50 years that the essence of effective management is motivation. The driving force of motivation is *incentive*--the pat on the back, and its mirror image, *disincentive*--fire the rascal.

Incentives can be *soft* (intangible) or *hard* (tangible). And the hard incentives can be *unspecified*, such as profit (never mentioned except for extras, and then only to restrict it), or *specified*, such as bonus clauses.

Soft Incentives	Soft Disincentives
Participation	Idleness
Creativity	Boredom
Recognition	Opprobrium

Richard Tucker and Charles McGinnis, the director and associate director, respectively, of the Construction Industry Institute, spoke about these things in their paper entitled "The Design Construct Management Challenge":

> An additional area of incongruence between design and construction organizations can be found in their respective motivational structures. Designers tend to derive significant satisfaction from professional activity and recognition. The commitment to quality, which in turn yields a high probability of client repeat business, is a major objective. Designers are sensitive to status, and often will respond more positively to some form of management recognition than to reasonable pay increases. They are given to conservatism for the most part in their professional activity. They are not risk takers, in fact, risk avoidance is a strong article of faith. The designer is interested in money, but the concern seems to be with achieving a reasonable threshold level of salary compensation which will permit maintenance of a standard of living on a par with professional peers at work and in the neighborhood. The design salary structure tends to be significantly lower than for construction executives with comparable qualifications and experience in their field of activity.
>
> The builder's principal driving force seems to be financial. By the very nature of his business he is a risk taker, with significant exposure to loss and with a high anticipation of reward if successful. Bonus payments for profitable projects are routine. He tends to be somewhat more mobile in moving between employers, following the work and driven by salary and bonus considerations. He obtains great satisfaction from surmounting the physical challenge of solving a difficult construction problem. He is sensitive to his status amongst peers, and he fights hard to obtain and retain improved status. He builds a reputation which is known widely in the industry, and which enhances his mobility between employers.

(It seems plain from the context of this paper that the word "bonus" as used here is internally generated, that is, from the employer, and not externally generated, that is from the project owner, which is the usual definition of a bonus incentive.)

The check list for hard incentives might appear as follows:

Hard Incentives (unspecified)	Hard Disincentives (unspecified)
Profit	Loss
Growth	Atrophy
Rewards	Bankruptcy

SOME WAR STORIES

When I was a young man and just starting out in the construction game, I recall having heard--over and over again--three startling things about contractors' bidding strategies:

- That some bid low, and expect to make their money on claims;
- That some bid low, and expect to make their money on change orders;
- That some bid low, and expect to make their money on their subs.

After decades of working with both owners and contractors, I have been able to verify only one and a half of those three postulates.

Some Contractors Do Abuse Their Subs

I did indeed work with a building contractor (I saw his bid with my own eyes) who totally brokered a job; he broke out every aspect of the work into about thirty different trades--masonry, glazing, carpets, etc.; obtained a bid price from each trade; totaled up the subs bids, and that became his bid, and he was low. Nothing for his own carrying costs, nothing for general conditions, nothing for overhead, management, or profit. Then he would get on the telephone and work the buy-down. "OK, I got the job," he would say, "now what's your *real* price?" Then he would haggle. His incentives were real. The job was for $2 million over 18 months. He needed a superintendent on the job with an office and a phone, he needed security guards, he needed sanitary facilities, safety features, and bid bonds. He needed to buy down $200,000 before he could break even. It must have been a gut-wrenching week on the phone. If I were the owner, I would worry about the time management on that job. In fact it did go sour, and it was the bonding company that called me in to see what I could put together at a reasonable cost to get the thing settled.

Change Orders Are "Creative Opportunities"

On the matter of change orders, I never experienced a contractor who relied on change orders for his sole profit source, but I did run into an electrical contractor who relied upon a change order to supply what was intended. The specification for 50 elaborate changeable message signs for a major turnpike called for a complex control panel mounted in a sealed box "similar to" that manufactured by a local reputable supplier, who had made all of the boxes for the other electrical signs on that road. When the shop drawings came in from that supplier, via a new electrical contractor, the drawings showed a piece of junk. It seems that the new contractor had rummaged around and found a bottom-of-the-line sample that the manufacturer had once supplied to a hamburger joint and convinced the skeptical supplier to base his price on that. It cost many thousands of dollars per box to correct that specifying error.

On the Matter of Contract Claims

I have never known of a contractor that depended on claims to earn a profit.

A caveat here about my own attitude on claims. There is a notion, and a very widespread one, that there is an explosion in contract claims. In two opportunities to look into the root of construction contract claims, I have never been able to prove this hypothesis. For one thing, there is no common definition of claims; for another thing, often claims are settled by an agency outside of the contracting agency such as an attorney general's office, and sometimes claims are paid out of a fund after a settlement conference, the results of which are unknown to the contract administrators. For these and a host of other reasons, it has been extremely difficult to get a handle on any specific hard data to show the trend in contract claims. In agencies such as turnpike authorities and the like, where comparative records are available, the total settlement for all claims should not come to more than 2 or 3 percent of the total construction budget. This can hardly be called an explosion.

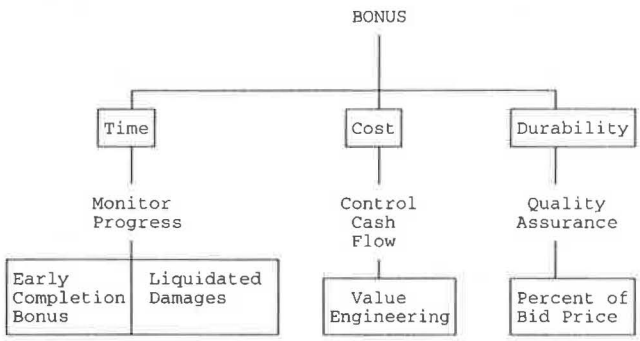
- The proliferation of claims is a perception without proof.
- A checklist of hard (specified) incentives as taken from a typical department of transportation specification might appear as follows:

Hard Incentives (specified)	Hard Disincentives (specified)
Bonus	Penalty
	Retainage
	Liquidated damages
	Bond forfeiture

It is clear that specified incentives have a strong bias on disincentives.

BONUS SYSTEM

Bonus systems tend to be focused on one or the other of three principal aspects of contract construction; time, cost, and durability. These systems can be chartered as shown in the following diagram.



In general, agencies tend to award a bonus, if any, for one of these aspects, but never for two or more. Early completion bonuses seem to be most in favor for commercial work such as office buildings, apartment buildings, factories, and the like. However, according to *NCHRP Synthesis 79, Contract Time Determination*, such incentives are finding their way into the transportation sector. The synthesis states the following:

INCENTIVE PAYMENTS

Agencies set bonus payments in an attempt to reward the contractor with an amount that is equal to the benefit of early completion or the cost of delayed completion. Bonus payments are used only for projects where there is compelling public need. Incentive or bonus payments are not required in order to include a provision for liquidated damages in the contract. (Contracts with incentive payment clauses always include provisions for liquidated damages.)

In the survey of state transportation agencies conducted for this synthesis, only 10 of 43 respondents indicated that they provide for incentive payments on construction contracts. Some of these agencies indicated that incentive payments have been used on selected or special projects (see Table 1). For example, a recent contract in Maine to repair a vital bascule bridge contained a provision for a $10,000 per day bonus for early completion.

The special provisions for incentive payments and liquidated damages used by the Illinois Department of Transportation in contracts for rehabilitation projects are shown in Figure 7. The provisions provide for a maximum payment period of 50 days at $5,000 per day. During a 1-month period no incentive was to be paid of damages charged; thereafter, there would be a damage charge of $10,000 per day (Figure 8). The contractor completed the work during the 1-month period.

Transportation officials are reluctant to use an incentive or bonus payment. If a contractor concentrates forces and equipment to complete a project early and collects a substantial bonus, the individuals setting the time limits and the agency are subject to criticism by the press, federal officials, and others, even though (a) later completion of the project most likely would have increased construction costs, (b) the bonus payment probably resulted in earlier use of the facility, and (c) other contractors had the same opportunity to place bids and collect bonus payments.

Arguments that have been presented against bonus payments include:

- Difficulty in budgeting an amount for bonus payments.
- Need for additional data to decide on an amount to rate.
- Value received may not be proportional to the additional cost.
- Increase in claims contractors.
- Provision in contract for liquidated damages is sufficient incentive.

The transit sector, too, has found it useful to rely on time incentives on some projects. Writing in *Transportation Research Record 1054* in a paper entitled "Using Accelerated Contracts With Incentive Provisions For Transitway Construction In Houston," Upton D. Officer had this to say about the Houston experience:

> As an incentive for better performance Metro offered a bonus of $5,000 per day for each day the AVL portion was completed early for a maximum of $450,000, which could be earned if completion occurred 90 days early (on the 270th day based on 360-day bid).
>
> In spite of the tight schedule and support problems the contractor finished this portion of the contract in 269 days and earned the full bonus of $450,000. The

contract performance period for this part was reduced from 975 to 269 working days, which was a reduction of 706 days or more than 23 months.

How much of the $450,000 bonus was profit? According to the contractor only about $100,000 was realized as profit to the company; the remainder was absorbed in increased costs for accelerating the construction schedule.

Because the old adage "Time is money," is widely believed and widely perceived by owning agencies, it seems likely that some combination of low bid and completion enhancement will be the most likely candidate to supplant the low-bid syndrome.

COST CONTROL PROGRAMS

Rewarding cost-saving schemes has been a part of the construction tradition in military and other federal contracts for some time under the rubric of "value engineering."

The idea of encouraging and rewarding innovation has apparently developed into a high art form in Europe. In a personal communication with the author, Boyd Paulson of Stanford University had this to say about European bidding practices:

> More interesting than the averaging system (which I think is sometimes used in Italy) is the normal Central European practice of soliciting substantial design alternatives from contractors at the bid stage. For example, in Germany I have seen highway bridge summaries involving 2 or 3 bids from 15 to 20 separate contractors for over 40 separate bids for the owner to choose from. The variations can be quite major, such as different pier spacings, structural systems, etc. Since the contractors know that their competitors are likely to improve on the owner's original design, and that innovation is frequently rewarded with a contract for a design different from the owner's, there is substantial incentive for innovation in design and construction methods. Clearly this also puts a heavy proposal burden on the contractors, but they must innovate if they want to compete. The owner's engineers obviously need to have the authority, integrity and the technical competence to objectively evaluate and select the best bid, even though it might not have the lowest first cost. Finally, it is helpful not to have so many lawyers to bring suit on every turn of the bidding procedures. It is no wonder that technology in some parts of Europe moves so much more quickly than ours, since *our* public agencies normally reject a contractor's bid if a contractor qualifies it with innovative alternatives. We thus tend to penalize innovation rather than reward it.
>
> American culture does not seem to be able to put so much trust in its public officials and their contractors."

In a study published by the Business Round Table entitled *Contractual Arrangements*, the role of incentives in commercial work is discussed in this manner:

THE ROLE OF INCENTIVES

Incentives are used by some owners in construction contracting in an effort to reduce the total contract cost, control the project schedule and support such performance goals as productivity, quality, safety, technological progress and innovation. Incentives, where used, should be designed to promote efficient contract management, achieve high performance standards, reward efficient contractors, and achieve some or all of the owner's specific project objectives. In general, some portion of the owner's risk is assigned to the contractor with a reward for accomplishing the objectives efficiently. Incentives, along with commensurate penalties, are only means to an end. They are only effective if the objectives are clearly understood by both parties and have a mutual benefit.

Incentives are primarily applicable to cost-plus contracts where they can be used to encourage the contractor to share the owner's risks on cost, schedule, quality or other desired project objectives. Appendix C provides a review of incentives that can be considered for construction contracts. The major disadvantages of incentives are the difficulty of arriving at fair and equitable targets, a reduction in the owner's control over the contractor's activities, and the costs of additional administration. Specific areas of difficulty normally encountered include:

- Negotiating problems to arrive at fair and equitable targets.
- Project engineering must be approximately 60% complete to establish the cost and schedule; otherwise, there are too many unknowns for the contract to be defined.
- If incentive provisions are exercised after the project is under way, the contract's general and special provisions must be reviewed and

renegotiated to give the contractor necessary control of the work. Similarly, a change in the owner's contract administration would be necessary.

Devising effective incentives is a very complex undertaking. Owners considering their use may want to focus on one contractor goal, job profit, and one or two owner goals such as controlling cost and schedule, thus making the incentive mechanism easier to manage and to understand for both parties. Owners should either develop in-house expertise or hire consultants versed in the subject to assure fair and equitable provisions in contracts.

The same publication also analyses incentives for various aspects of contractor performance in the following manner:

CONTRACTOR PERFORMANCE INCENTIVES

In this type of cost-plus-incentive contracting, the contractor earns a bonus or a penalty that adds to or subtracts from his earned fee, based on his performance in the field. The items of performance normally considered are very difficult to measure in an objective way, so a performance norm and method of evaluation must be established in the contract against which the subjective performance factors are compared. A performance norm varies from contractor to contractor and sometimes requires considerable time to establish between an owner and a contractor. Four quarters of operation are usually used to establish a performance norm. The use of performance incentive contracting is more appropriate where owners and contractors have worked together before, thus establishing a more equitable basis for setting performance goals.

Performance is measured against items that have the most significant impact on the construction cost and schedule. Some of them are:

- Craft-labor productivity: A measure of how well the contractor manages his craft labor through planning, scheduling, furnishing of skilled workers, training, crew mixes, and other criteria.
- Indirect costs: A measure of the results against an established budget.
- Schedule: A measure of how well the contractor meets the milestone dates set for the project.
- Safety: A measurement of safety on the project is based not only on injury statistics but on the contractor's training inspections, knowledge of, and attitude toward safety.
- Quality of construction work: To encourage the contractor to meet quality goals which may be higher than normally found in the construction industry.
- Responsiveness: Contractor reaction to changes in the site conditions, objectives of the project, and scope of work.

BONUSES FOR QUALITY

TRB has supported the effort of the FHWA to encourage the paying of bonuses for quality work. The Committee On Quality Assurance and Quality Control has recommended several papers for publication and conducted several sessions on the topic. In a forthcoming synthesis, the author describes some of the experiences in the various states.

The success of the QA system in West Virginia has been reported on by Steele and Higgins. They decided early on that only through the concepts of probability could they hope to develop a satisfactory program. They targeted four construction items--portland cement concrete, bituminous concrete, aggregate base course, and embankment construction. They divided their QA system into two distinct functions:

1. Process control by the contractor, and
2. Acceptance inspection in testing by the department.

Another important aspect of the West Virginia experience was a cooperative program for the certification of technicians. A continuing annual training and certification process keeps the program up-to-date. The program has been well received and the use of a qualified technician by industry is now a specification requirement on all department projects. Some of the significant advantages noted with the West Virginia program are as follows:

1. Conflicts between the department and the contractor-producer are greatly reduced because there is no longer a question of test value validity and test results are available to the contract-producer sooner;
2. The contractor-producer can control the number and quality of testing personnel necessary for control of the product and does not have to wait for the department technician to start production;
3. The contractor-producer is able to make better use of good but borderline materials by having control of the process; and

4. Faster test results and knowledge of trends allow more positive response by the contractor-producer, this results in less loss of production and a significant reduction in production or use of nonspecification material.

On the question of bonuses and penalties, Steele and Higgins believe that a bonus for good work is psychologically an excellent motivator; they say that a good case can also be made that a cost reduction for deficient work is an equally persuasive motivator.

They draw the following conclusions from their experience in West Virginia:

1. Performance specifications are workable, practical, and economical when properly implemented through systems-engineering techniques;
2. An agency that uses appropriate performance specifications can cause a decrease in the consumer's risk and generally can provide the opportunity for a decrease in producer's risk--in any event, the risk becomes manageable;
3. The contracting industry is fully capable and competent to provide the QC system necessary for production of a finished project that will meet the requirements of the plans and specifications; and
4. An agency that uses performance specifications can, by using an appropriate QA system, shift its activity emphasis to verifying the adequacy of the contractor's control systems as the principal means of ensuring that the specified facility is received.

One testimony to the success of the West Virginia experience came from a concrete supplier. He stated flatly that automated central mix had enabled them to realize some cost reductions for good process control. It was noted that within 1 year from opening a central mix plant, they had reduced the cement content of 3,000-lb, 6-bag, Class B concrete from 6.25 bags of cement to 5.5 bags of cement. They are so enthusiastic with the Department of Highways procedure that they consider that customer as preferred business and "their jobs at or below rates for comparable commercial jobs."

Another testimony on the West Virginia experience came from the FHWA. A spokesman there noted that the West Virginia Highway Department used the same manpower in the 1970s as in the 1960s to meet a workload that was five times higher than that of the 1960s.

Expanding on the notion of incentive features, Hughes believes that they are the primary reason that improved densities have been obtained in Virginia during the six years from 1976 to 1983.

TABLE 1 ANNUAL AVERAGES IN VIRGINIA

Year	Average Density (%)	Standard Deviation (%)	Pay Factor (%)
1976	91.3	1.3	97.3
1978	91.6	1.6	97.3
1979	92.0	1.5	97.9
1980	92.6	1.3	98.9
1981	92.7	1.2	99.7
1982	93.1	1.2	100.4
1983	93.1	1.1	100.4

The improved density achieved is readily apparent. Average densities increased from 91.3 to 93.1 percent over the entire period. This was entirely attributed to a new specification that allowed for adjusted pay factors including an incentives provision. That specification is as follows:

> Payment for the quantity of material calculated as being under the standard normal distribution curve and that calculated as having a density equal to or greater than 94% of theoretical maximum density will be at the contract unit price per ton for the type bituminous concrete specified. Price adjustment factors as shown in Table 1 will be applied to the quantity of material calculated as having a density less than 94% of theoretical maximum density and being outside the standard normal distribution curve in accordance with the following:

Percent of Theoretical Maximum Density	Quantity in Excess of (%)	Price Adjustment Factor (%)
Less than 88	0	85
88 to 90	3	90
90 to 92	32	95
92 to 94	52	105

This specification achieved greater density and also achieved higher payment levels for the contractors. Pay factors increased from 97.3 percent of bid price to 100.4 percent of bid price. The actual distribution of pay factors in 1983 is shown in Figure 1:

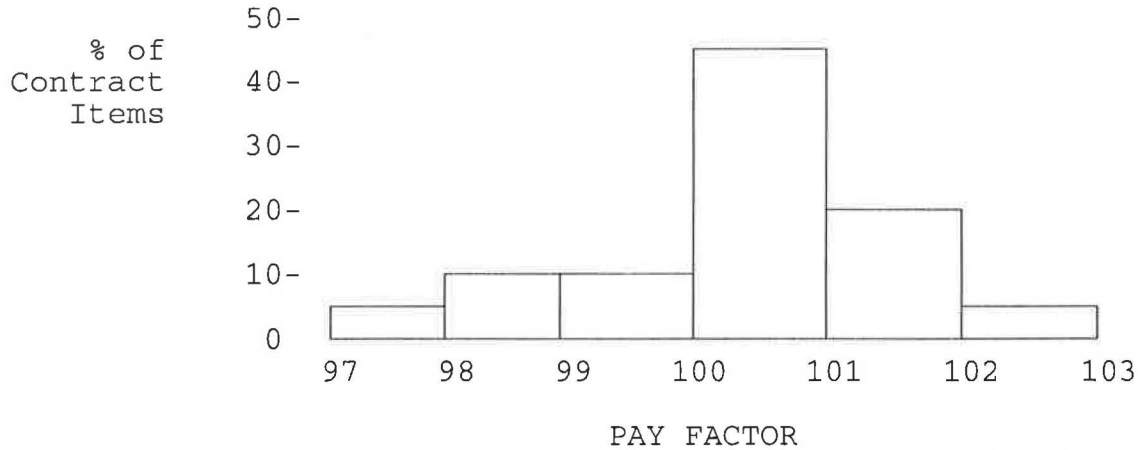


FIGURE 1 Distribution of pay factor for 1983.

AN OVERVIEW

Also in 1984, Kopac surveyed the practices in all of the states with regard to acceptance plans for bituminous concrete compaction. He found 17 agencies that include statistical acceptance plans. He also found several problems with those plans.

Of the 17 agencies, 7 have acceptance plans that give no consideration to the variability in compaction. In these states, only estimate of the mean is needed to determine acceptance. (This means that a submitted lot that has an estimated mean compaction of 98.0 percent and a standard deviation of 0 percent, for example, is treated for acceptance purposes as identical to a lot that has an estimated mean compaction of 98.0 percent and a standard deviation of 5 percent.)

Several of the 17 agencies have acceptance plans that are statistically unsound. One agency, for example, places the same minimum density requirement on individual samples taken from a lot regardless of the total number of samples in that lot. Thus, in that state, the more samples taken from a contractor's lot, the greater the probability that the contractor's work will be deemed unsatisfactory, even if it is actually good. A similar situation exists in another agency's acceptance plan. That agency requires 5 to 10 samples per lot but does not change the acceptance criteria to account for the different sample sizes. It can be demonstrated that, for the acceptance plan in question, the use of five samples would result in full-payment acceptance of material that is estimated to be at least 69 percent within tolerance. If 10 samples are taken, the estimated percentage within tolerance must be at least 75 percent for full-payment acceptance. A decision to use a sample size of 10 instead of 5 could therefore be harmful to a contractor who is producing good material.

Many acceptance plans are not as efficient as they might be. Those agencies that require multiple random samples and then calculate only the sample average are not making full use of available test results. Of the 10 agencies that do use available test results to assess the degree of compaction variability present in the lot, only one does so by computing the standard deviation. It can be shown that the standard deviation method is more accurate, or requires smaller sample sizes to achieve the same accuracy, than the range method. AASHTO is currently considering revision of its standard recommended practice for acceptance sampling plans; one of the changes that has been proposed is the use of the standard deviation method as an alternative to the range method.

Lot sizes, samples sizes, test procedures, and acceptance limits all vary considerably among the states. In regard to sample size (which typically ranges from n = 3 to n = 7), it is surprising that larger sample sizes are not used in conjunction with the nuclear density test. The test is nondestructive and can be quickly performed. By taking 20 samples, for example, a better estimate of quality could be obtained at little or no extra cost.

Kopac concluded with a valuable check list of items that should be included in an acceptance plan:

1. Acceptance plans should provide for a measure of not only the mean but also the variability;
2. The standard deviation is a better measure of variability than the range, and it should be used in all cases;
3. Provisions should be made to adjust acceptance

criteria to reflect changes in sample size;

4. Larger optimum sample sizes should be used where possible;

5. Where possible, price adjustment schedules should be related to expected performance;

6. Pay factors greater than 100 percent should be considered where increased performance can be demonstrated;

7. Continuous price adjustment schedules should replace graduated schedules; and

8. Operating characteristic curves should be used to assist in the development of acceptance plans.

Other improvements will become possible as a better understanding of materials quality characteristics is obtained. More multicharacteristic acceptance plans should come into being, and more rational price adjustment systems should be developed. A greater degree of nationwide uniformity can and should be obtained, even if in the interim it is achieved through an arbitrary but reasonable price adjustment system.

Newman and Hejl, in a paper entitled *Contracting Practices and Payment Procedures*,[1] made these observations:

> There are several different areas in which incentive and disincentive clauses can be applied, but addressed here are only the provisions regarding the completion of a project (a) on or ahead of schedule, and (b) at or better than the minimum acceptable quality standards. Most provisions are disincentives.

BONUSES

Highway agencies are less comfortable with awarding bonuses to contractors as an incentive for early completion of projects. Some states forbid it by law. The few agencies that do pay bonuses do so only on projects of an emergency nature, on projects that disrupt businesses, or on projects that are an extreme inconvenience to the traveling public. Most agencies that have used bonus clauses have applied them only one or two projects.

The FHWA published in the June 13, 1984, edition of the Federal Register (49 FR 24374) a notice of rescission of regulation concerning bonus payments. It had been FHWA policy before that time to not participate, directly or indirectly, in any part of a bonus to the contractor for early completion of a project. However, the results of an FHWA-initiated study under the National Experimental and Evaluation Program showed that the use of bonus (incentive and disincentive) provisions was a valuable construction tool and was cost justified. It is believed that the bonus provisions will be used mainly on 4R and bridge reconstruction projects, where analysis shows such provisions to be in the public interest, with lesser use on other types of projects.

Contractors favor the use of bonuses. Those interviewed were successful in collecting awards on projects with bonus clauses. Most believe that if they are to be assessed liquidated damages for late completion, they should be given the opportunity to earn bonuses for early completion.

The contractors and the highway agencies in favor of awarding bonuses believe that the amount assessed for liquidated damages should equal the amount awarded for bonuses.

CONCLUSION

It is envisioned that a more reasonable alternative to the low-bid syndrome would be an amalgam that takes into account all of the factors discussed. Of course, the initial price is important and must be considered. In addition, innovation and value engineering should be encouraged. Let this factor, the adjusted price considering innovative changes, be P. Secondly, it is clear that time is an important consideration in construction, so let there be a factor T. Finally, to ensure a consideration of quality determinants, let us have a factor Q. If T is a decimal number (a contractor who planned to finish the project in 90 of the allotted time would insert 0.9 percent for T, and if a QC rating 10 percent above average would imply 1.1 as Q, etc., then all of these complex factors can be reduced to a simple formula:

$$\text{Bid factor} = (P + T)/Q$$

Such a rational system for contracting for construction services would go a long way toward pulling us out of the low-bid syndrome.

It is plain that if we fail to recognize our own inadequacies, then somebody else will and take over the process of construction from usy. It is for us, the practitioners, to put our own system in order.

ENDNOTE

1. In *Transportation Research Record 986*.