automated processes that are most essential to running the department's three business groups. Included are systems for financial management, budgeting, project accounting, federal aid billing and tracking, accounts payable, human resources management, and accounts receivable. These systems are to replace the department's existing accounting system. The CMS will interface with at least two of the foundation systems.

In another important venture, the department is actively gathering and analyzing bid and bidder information to detect bid collusion and rigging patterns. With solid data provided from such systems as CMS, the potential advantages for the department are enormous. One single such case in 1983 resulted in the department gaining a $1.5 million settlement. More competitive prices are now anticipated because such bid collusion cases are publicized in the news media.

Data processing systems for general maintenance and department resources are also being revamped. A new system is being developed to improve and integrate department processes dealing with maintenance management, automated inventory management, and equipment management. There may be a need to integrate some functions from CMS and the new maintenance management system.

There are other improvements to be made to CMS. Processes such as monitoring percentage goals by contract for minority business enterprises are to become more automated and integrated for CMS and other systems. The CMS user community regularly submits ideas for improving the system. Improvements will probably continue as long as system changes bring about further increases in productivity or improvement in services.

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Adjusted Pay Schedules: New Concepts and Provisions

RICHARD M. WEED

ABSTRACT

Shortly after the AASHTO Road Test had furnished a wealth of statistical data on pavement construction and performance, highway agencies began to use this data to develop end-result specifications based on statistical concepts. These specifications usually included adjusted pay schedules, the development of which was sometimes quite arbitrary. More recently, attempts have been made to improve both the accuracy with which pay schedules are established and the fairness with which they are administered. The rationale underlying several recent advances in the state-of-the-art is discussed. Included are the use of the principle of liquidated damages to relate pay reductions to the anticipated monetary loss resulting from substandard work, the development of the crediting concept to overcome a basic inequity of many existing pay schedules, and the establishment of bonus provisions that provide additional incentive by awarding payment slightly in excess of the contract price for superior quality work.

The AASTHO Road Test generated a wealth of data relating pavement quality to performance. Shortly thereafter highway agencies began to use this data to develop end-result specifications based on statistical concepts. It was found that various statistical measures effectively described the characteristics that were desired and that, by performing tests on random samples taken at the job site, it was possible to determine the extent to which the desired results had been achieved. Then, depending on the degree of compliance, adjusted pay schedules were used to award an appropriate level of payment. A recent report (1) traces the evolution of specifications of this type.

Although not all highway agencies embraced this new approach with equal enthusiasm, it was difficult to deny the many advantages that statistical end-result specifications offered over the earlier "method" specifications. A major advantage is the practical mean end-result specifications provide for dealing with marginal quality. A construction item that falls just short of the specified quality level does not warrant rejection but neither does it deserve 100 percent payment. Adjusted pay schedules provide a logical and convenient way to accept work that is only slightly deficient. Another desirable characteristic is the proper division of responsibility. By defining the control of the construction process as the contractor's responsibility and the acceptance of the work (end result) as the highway agency's responsibility, a much firmer legal basis is established for those situations in which truly unsatisfactory work must be rejected. Also, by clearly defining acceptance criteria and random sampling procedures, the risks to both the contractor and the highway agency can be controlled and known in advance. Under the earlier method-type specifications, a contractor's bid was often influenced by the reputation of the engineer in charge of the project. Still another advantage of the end-result approach is that it forces the specifying agency to recognize the existence of inherent variability and to deal with it in a realistic manner. Many of the earlier specifications had requirements that were not practically achievable by normal construction standards. And finally, because the random sampling plans used with these specifications avoid the biases that are likely to occur when an inspector attempts to select a "representative" sample, reliable estimates of the as-built construction quality can be made. This information can also be used as feedback to determine whether future modifications of the specifications are desirable.

TYPES OF PAY SCHEDULES

There are two basic types of pay schedules, stepped and continuous. Stepped pay schedules define discrete intervals of the quality measure and assign a specific pay factor for each interval. Continuous pay schedules express the pay factor in equation form as a function of the quality measure. Although both types can be constructed to have essentially the same long-term performance, continuous pay schedules offer certain advantages that will be discussed shortly.

A typical stepped pay schedule is shown in Figure 1. In this example pay factors are dependent on the level of percent defective, a commonly used quality parameter representing the amount of material falling outside specification limits. This particular pay schedule pays a maximum of 100 percent and, if the option to require removal and replacement of extremely defective material is not exercised, a minimum of 50 percent.

Range of Percent Defective	Pay Factor (Percent)
0.0 - 10.00	100
10.01 - 20.00	95
20.01 - 30.00	90
30.01 - 40.00	80
40.01 - 50.00	70
50.01 - 100.00	50*

*Any lot that exceeds 50.00 percent defective will be considered unacceptable and may be required to be removed and replaced at the expense of the contractor. If, for practical purposes, this option is not exercised, the lot may remain in place and receive the minimum pay factor of 50 percent.

FIGURE 1 Typical stepped pay schedule.

Equation 1 illustrates a typical continuous pay schedule in which PF represents the pay factor in units of percent and PD stands for percent defective.

$$PF = 105 - 0.5\ PD \quad (1)$$

As is the case with the stepped pay schedule, an option to require removal and replacement of extremely defective material would probably be included with this pay equation. Equation 1 will pay a maximum of 105 percent unless an additional constraint is added to limit the pay factor to some lower value, as would be the case if an agency wished to limit the maximum pay factor to 100 percent.

Although stepped pay schedules are in more common use, continuous pay schedules are rapidly gaining favor. The difference in payment between two adjacent intervals in a stepped pay schedule can be quite substantial and, when the quality measure happens to fall close to an interval boundary, this can lead to disputes over measurement precision, round-off rules, and so forth. With a continuous pay schedule there is a smooth progression of adjusted payment as the quality varies and, consequently, the potential harshness of having just missed the next higher pay level is completely avoided.

ESTABLISHMENT OF APPROPRIATE PAY LEVELS

A vital concern in the development of adjusted pay schedules is the determination of appropriate pay levels for various levels of quality. Over the years several methods (2,pp.8-9; 3-6) have been proposed, and, where there was little or no information relating quality measures to performance, the methods have necessarily been quite arbitrary. In cases for which quality-performance relationships have been established, one of the more rational methods of establishing pay schedules is based on the legal principle of liquidated damages: the pay schedule is designed to withhold sufficient payment at the time of construction to cover the cost of future repairs made necessary by defective work.

This method is particularly suitable for rigid pavement and, to a lesser degree, for flexible pavement. For both types of pavement, the AASHTO Design Guide (7) gives the number of equivalent 18-kip load applications that can be sustained as a function of several common quality measures. Ordinarily, a pavement is designed to sustain a specified number of load applications before major repair (overlaying with bituminous concrete) is required. If, due to construction deficiencies, the pavement is not capable of withstanding the design loading, it will fail prematurely. The necessity of repairing this pavement at an earlier date results in an additional expense that, because it invariably occurs long after any contractual obligations have expired, must be borne by the highway agency. It is the purpose of the adjusted pay schedule to withhold sufficient payment at the time of construction to cover the extra cost of these premature repairs.

There are two interesting consequences of the liquidated-damages approach. First, because the pay adjustments are based on the economic impact of a departure from the specified quality level, they may be positive as well as negative. For quality in excess of the design level, the highway agency receives a tangible benefit in terms of extra service life and, accordingly, this method awards a small bonus. Second, for departures from the desired quality in either direction, the pay adjustments by this method are less severe than those derived by some of the other methods. For example, one of the earlier approaches suggested for pavements was to set the pay factor equal to the ratio of as-built load-carrying capacity to the design load-carrying capacity. However, this would produce a pay factor of zero for a pavement judged to be so defective that immediate repair is necessary. This is considered inappropriate because, unless unusually drastic repairs are required, even seriously defective pavement still has considerable value as the subsystem on which the next generation of overlay will be placed. The highway agency has, therefore, been damaged only to the extent of the present worth of the cost to restore the serviceability of the pavement throughout its intended design life. The complete development of this concept is discussed elsewhere (1,5).

NEED FOR A MORE UNIFORM SYSTEM

A recent paper (8) calls attention to the considerable disparity among the pay schedules used by different highway agencies. In one dramatic example, based on specifications for bituminous concrete, a particular level of quality would receive 100 percent payment in one state and no payment at all in another. A situation such as this can only serve to undermine the credibility of state highway agencies and points out the need to establish a uniform pay adjustment system that is legally and technically sound. It is hoped that current efforts to establish meaningful quality-performance relationships for various construction parameters can be coupled with the liquidated-damages approach to accomplish this objective.

LEGAL CONSIDERATIONS

The legal concept of liquidated damages may properly be applied whenever it is impossible or impractical to quantify the actual damages. Because pay schedules are designed to recoup future losses that can only be estimated at the time of construction, such schedules clearly qualify for this approach.

As a general rule, liquidated-damage clauses are considered acceptable whereas penalty clauses are not. The following quotation is from Sweet (9,p.404):

> If enforcement of a clause would punish a breaching party by awarding an amount disproportionately high to anticipated or actual damages, the clause will not be enforced even if labeled as a damage liquidation clause. Conversely, a clause labeled a penalty will be enforced if it otherwise meets the test of damage liquidation.

In other words, no matter how a specifying agency chooses to label a pay reduction clause, the magnitude of the pay reduction must be reasonably commensurate with the amount of damage actually suffered. However, this need not be interpreted to mean that the amount of damage must be estimated with great precision. Sweet (9,pp.403-404) cites a Supreme Court decision that includes the following commentary on liquidated-damage clauses:

> When that intention is clearly ascertainable from the writing, effect will be given to the provision, as freely as to any other, where the damages are uncertain in nature or amount or are difficult of ascertainment or where the amount stipulated for is not so extravagant, or disproportionate to the amount of property loss, as to show that compensation was not the object aimed at or as to imply fraud, mistake, circumvention or oppression. There is no sound reason why persons competent and free to contract may not agree upon this subject as fully as upon any other, or why their agreement, when fairly and understandably entered into with a view to just compensation for the anticipated loss, should not be enforced.

In simpler language what this appears to say is that two contracting parties may agree on the amount to be withheld in the event of noncompliance, and the courts will uphold this agreement provided the stipulated amount is reasonably appropriate for the damages actually suffered and there is no element of deception, either willfully or by mistake. Unfortunately, although the effect is certainly unintentional, many existing specifications come perilously close to violating the latter requirement. However, before discussing this basic problem, it will be worthwhile to review the methods by which pay schedules are analyzed and compared.

ANALYSIS OF ADJUSTED PAY SCHEDULES

To analyze any type of acceptance procedure, it is customary to construct its operating characteristic (OC) curve that typically gives the probability of acceptance on the Y-axis as a function of various levels of the quality parameter on the X-axis. For adjusted pay schedules a similar procedure is used except that, instead of probability of acceptance, expected payment is plotted on the Y-axis. Consequently, OC curves of this type are sometimes referred to as expected payment (EP) curves. Although the methods for constructing these curves are tedious and somewhat complex, they are quite easy to apply when computer assistance is available (1,10-12).

A recently developed software package (1,12) can be used to construct the expected payment curves for adjusted pay schedules that are based on percent defective such as those illustrated in Figure 1 and Equation 1. This is shown in Figures 2 and 3 in which it can be seen that little specialized knowledge is required to run this interactive program.

For ease of comparison the expected payment curves have been plotted in Figure 4. Because the maximum pay factor awarded by the stepped pay schedule in Figure 1 is 100 percent, its OC curve starts at 100 percent and gradually drops to the minimum pay factor of 50 percent as the percent defective increases from zero to 100 percent. The practical consequence of this is that, in order to achieve a long-term average pay factor of 100 percent, a contractor must consistently produce material that has essentially zero percent defective. The situation is quite different for the continuous pay schedule given by Equation 1. Because it awards bonus pay factors up to a maximum of 105 percent, its OC curve is higher, permitting a contractor to obtain an average pay factor of 100 percent by producing material that is 10 percent defective. The implications of this are discussed in the next section.

To illustrate the point made earlier that stepped and continuous pay schedules can be constructed to have the same long-term performance, an additional computer run was made using the modified pay schedule shown in Figure 5. It can be seen that the expected pay factors in this figure are very nearly the same as those obtained with the continuous pay schedule shown in Figure 3.

A BASIC PROBLEM

To illustrate a basic deficiency that exists with many statistical specifications that include adjusted pay schedules, it is first necessary to understand what is meant by the acceptable quality level (AQL). The AQL is that level of quality, usually defined in terms of some minimal degree of deficiency, that the specifying agency is willing to accept at 100 percent payment. An appropriate level for the AQL may be derived either theoretically or empirically and a commonly used value is 10 percent

```
     ENTER '1' IF A CONTINUOUS PAY SCHEDULE IS TO BE USED,
OR ENTER THE NUMBER OF STEPS IF A STEPPED PAY SCHEDULE IS
PREFERRED.

¬
6

ENTER:       THE UPPER PERCENT DEFECTIVE      ( 6 PERCENT DEFEC-
             LIMIT FOR EACH STEP               TIVE VALUES)

¬
10 20 30 40 50 100

ENTER:     THE  6 PAY FACTORS ASSOCIATED
           WITH THE  6 PAY STEPS.              ( 6 PERCENT VALUES)

¬
100 95 90 80 70 50

ENTER:     THE SAMPLE SIZE                        (AN INTEGER ≥ 3)

¬
5

ENTER:     1) THE PERCENT DEFECTIVE RANGE OF        (TWO PERCENT
              INTEREST                               VALUES)
           2) THE EP CURVE PLOT INCREMENT            (A PERCENT)

¬
10 90 10

             POINTS ON THE EXPECTED PAYMENT CURVE
             ------------------------------------

             SAMPLE SIZE        =    5

     STEP          QUALITY INTERVAL               PAY FACTOR
     ----    ------------------------------       ----------
       1       0.0% ≤ PCT. DEF. ≤  10.0%            100.0%
       2      10.0% < PCT. DEF. ≤  20.0%             95.0%
       3      20.0% < PCT. DEF. ≤  30.0%             90.0%
       4      30.0% < PCT. DEF. ≤  40.0%             80.0%
       5      40.0% < PCT. DEF. ≤  50.0%             70.0%
       6      50.0% < PCT. DEF. ≤ 100.0%             50.0%


             PERCENT              EXPECTED
             DEFECTIVE            PAY FACTOR, %
             ---------            -------------
               10.00                 96.138
               20.00                 90.049
               30.00                 82.218
               40.00                 73.505
               50.00                 65.052
               60.00                 58.014
               70.00                 53.203
               80.00                 50.764
               90.00                 50.046
```

FIGURE 2 Development of expected payment curve for the stepped pay schedule in Figure 1.

```
     THIS OPTION COMPUTES THE EXPECTED PAY FACTOR BASED ON A
GIVEN PAY SCHEDULE AND SAMPLE SIZE.

     ENTER '1' IF A CONTINUOUS PAY SCHEDULE IS TO BE USED,
OR ENTER THE NUMBER OF STEPS IF A STEPPED PAY SCHEDULE IS
PREFERRED.

¬
1

ENTER:     1) B0                                  (A PERCENT VALUE)
           2) B1                          (COEFICIENT OF LINEAR TERM)
           3) B2                       (COEFICIENT OF QUADRATIC TERM)

¬
105 -0.5 0

ENTER:     1) THE MAXIMUM PAY FACTOR                (THREE PERCENT
           2) THE MINIMUM PAY FACTOR                 VALUES)
           3) THE PERCENT DEFECTIVE VALUE
              BEYOND WHICH THE MINIMUM PAY
              FACTOR IS ASSIGNED
```

FIGURE 3 Development of expected payment curve for the continuous pay schedule given by Equation 1.

```
-
105 50 50
            ENTER:     THE SAMPLE SIZE                       (AN INTEGER ≥ 3)
-
5
            ENTER:     1) THE PERCENT DEFECTIVE RANGE OF       (TWO PERCENT
                          INTEREST                              VALUES)
                       2) THE EP CURVE PLOT INCREMENT           (A PERCENT)
-
10 90 10

                          POINTS ON THE EXPECTED PAYMENT CURVE
                          ------------------------------------

                          SAMPLE SIZE          =     5
                          B0                   = 105.000
                          B1                   =  -0.500

                          MAXIMUM PAY FACTOR = 105.000
                          MINIMUM PAY FACTOR =  50.000

                          PERCENT DEFECTIVE
                          FOR WHICH PAY FAC-
                          TOR IS MINIMUM     >  50.000

                          PERCENT              EXPECTED
                          DEFECTIVE            PAY FACTOR, %
                          ---------            -------------
                            10.00                 99.943
                            20.00                 94.281
                            30.00                 87.159
                            40.00                 78.476
                            50.00                 69.140
                            60.00                 60.653
                            70.00                 54.428
                            80.00                 51.094
                            90.00                 50.069
```

FIGURE 3 (continued)

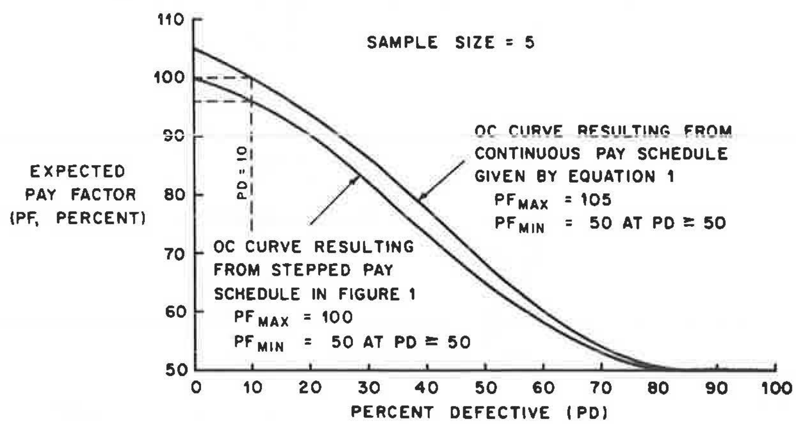

FIGURE 4 Typical operating characteristic curves.

```
         SAMPLE SIZE          =     5
STEP          QUALITY INTERVAL               PAY FACTOR
----     ---------------------------         ----------
 1        0.0% ≤ PCT. DEF. ≤   5.0%            105.0%
 2        5.0% < PCT. DEF. ≤  15.0%            100.0%
 3       15.0% < PCT. DEF. ≤  25.0%             96.0%
 4       25.0% < PCT. DEF. ≤  35.0%             90.0%
 5       35.0% < PCT. DEF. ≤  50.0%             80.0%
 6       50.0% < PCT. DEF. ≤ 100.0%             50.0%
         PERCENT                 EXPECTED
         DEFECTIVE               PAY FACTOR, %
         ---------               -------------
           10.00                    99.987
           20.00                    93.944
           30.00                    86.354
           40.00                    77.471
           50.00                    68.264
           60.00                    60.092
           70.00                    54.181
           80.00                    51.033
           90.00                    50.065
```

FIGURE 5 Modified stepped pay schedule equivalent to the continuous pay schedule in Figure 3.

defective. When the AQL has been defined, this information must be communicated to the contractor so that it is clear at the outset what level of quality is required. It is in this area that many existing specifications are unintentionally deceptive.

Whether the AQL is explicitly stated or only implied, it is the interpretation of the AQL that causes the problem. For example, in the stepped pay schedule shown in Figure 1, it is implied that material that is 10 percent defective or less is acceptable because this interval corresponds to 100 percent payment. However, only after the OC curve in Figure 4 has been constructed does it become apparent that this pay schedule will not pay 100 percent, in the long run, when the material is exactly 10 percent defective. In reality a contractor who produced material that was consistently 10 percent defective would receive an average pay factor of about 96 percent. To approach 100 percent payment, the percent defective would have to be almost zero.

In most cases this would require a distinctly different target value for the process mean, much tighter quality control, or both.

The theoretical explanation of this flaw is quite simple and the culprit, of course, is the fact that the highest pay factor in the pay schedule is 100 percent. When the true quality level is exactly at the AQL, approximately half of the sample estimates will be higher and receive 100 percent payment and the other half will be lower and receive some pay reduction. Consequently, the average pay factor will be less than 100 percent. Ironically, a perfectly good statistical estimator (percent defective) has been biased by the manner in which it has been used.

A quantitative example will serve to emphasize this point. If the stepped pay schedule shown in Figure 1 were included in a specification for portland cement concrete, the in-place cost of a structure might be $400 per cubic yard whereas the price an independent producer charges the contractor for the raw concrete would be about $50 per cubic yard. Assuming a design strength of 3,000 psi and a typical within-lot standard deviation of 300 psi, a target strength of 3,000 + 1.282(300) = 3,385 psi would produce exactly 10 percent defective. However, if concrete of this quality were consistently supplied, the OC curve for the stepped pay schedule shown in Figure 4 indicates that an average pay factor of 96 percent would be received. The pay reduction of 4 percent, when applied to the in-place cost of the concrete, amounts to $16 per cubic yard. Although this is an unfair burden to place on the contractor for material that is technically acceptable, an even greater problem occurs if the contractor passes the pay reduction back to the producer. When applied to the cost of raw concrete of $50 per cubic yard, the pay reduction of $16 per cubic yard could result in a ruinous loss to a producer who supplied material exactly at the AQL.

There are several things wrong here. Contractors or producers who accept the AQL as a suitable target value and supply material of this quality will suffer unexpected and undeserved pay reductions. Those who sense that a higher level of quality is required, but who do not have the expertise to construct or interpret OC curves, may either raise their prices exorbitantly or elect not to bid at all. Eventually, it will become apparent that a substantial overdesign is necessary, but this may raise both the quality and the price above levels that are justifiable from a benefit-cost standpoint. In the previous example, although a target strength of 3,385 psi would have been considered satisfactory, an average strength of nearly 4,000 psi would be required to assure essentially 100 percent payment.

Many existing statistical specifications have this shortcoming to some degree and it is not surprising that industry groups are generally opposed to them. Fortunately, it is quite easy to correct this problem once it has been recognized.

TWO SOLUTIONS

The problem is that many statistical specifications do not pay 100 percent, on the average, when the work is exactly at the AQL. Two solutions are possible, both requiring the use of pay factors greater than 100 percent. The first, usually referred to as the "crediting concept," allows pay factors greater than 100 percent to offset lower pay factors, subject to certain restrictions. The major restriction is that the overall average pay factor for the project is still limited to a maximum of 100 percent. Most agencies would probably want to apply this restriction to shorter intervals (perhaps monthly billing periods) so that a buildup of credit in the early stages of a project would not lessen the incentive to produce high quality in the later stages or vice versa. Another desirable restriction is that credit may not be applied to lots that fall below some specified low level of quality (perhaps the level at which the agency reserves the option to require removal and replacement). This procedure is described in a recent paper (13) and is capable of producing an average pay factor of essentially 100 percent at the AQL. One weakness, however, is that its effectiveness is a function of the number of lots included in each pay interval. If there are relatively few lots, the average pay factor may still be slightly less than desired.

The second method, termed a "positive incentive" or "bonus" provision, is somewhat simpler to administer and is slightly more effective at producing an average pay factor of 100 percent at the AQL. Supported for several years by the FHWA (14), this provision allows lots of exceptionally high quality to receive pay factors greater than 100 percent without being subject to the restrictions imposed with the crediting concept. To justify this approach the specifying agency must be convinced that it receives a tangible benefit as the result of superior quality. For either rigid or flexible pavement, the AASHTO Design Guide (7) can be used to demonstrate that an increase in quality produces an extended service life. Consequently, a bonus is justified provided no other mode of failure negates this effect. The appropriate amount of bonus may be determined by procedures outlined in two recent publications (1,5) and is usually relatively small. For other items of construction, for which quality--performance data may be scarce or nonexistent, it is a matter of judgment whether the bonus provision or the crediting concept is the more suitable procedure.

SUMMARY AND CONCLUSIONS

Since shortly after the AASHTO Road Test, there has been a continuing trend on the part of state highway agencies to develop statistically based construction specifications with adjusted pay schedules. More recently, additional work has been done to properly quantify the magnitude of the pay adjustments. The method developed to satisfy the legal test of liquidated damages, by which the pay schedule is designed to withhold sufficient payment at the time of construction to cover the cost of future repairs made necessary by defective work, is advocated as being among the most rational and defensible.

It was noted that both stepped and continuous pay schedules are in common use and that both can be constructed to provide essentially the same long-term performance. However, because of the smooth progression of payment as the quality varies, continuous pay schedules are likely to be more palatable to all concerned.

The recent work also led to the discovery that many existing pay schedules are flawed in the sense that they do not pay 100 percent, on the average, when the work is exactly at the acceptable quality level and that, in some cases, this can impose a severe hardship on contractors. There are two methods by which this inequity can be corrected, both requiring the use of pay factors greater than 100 percent. In those cases for which bonus payments are not considered appropriate, the crediting concept can be used. This concept allows pay factors greater than 100 percent to offset lower pay factors, subject to certain restrictions. In those cases in which extra quality translates into a tangible benefit of some kind, an actual bonus provision can be used. The adoption of either of these provisions will result in fairer treatment of contractors and may eventually help to improve their generally negative attitude toward specifications of this type.

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Incentive and Disincentive Specification for Asphalt Concrete Density

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ABSTRACT

The background for a specification that includes both positive and negative price adjustments for the density of asphalt concrete is presented. The results that have been obtained since the specification was introduced in 1978 are described. The incentive features of the specification are emphasized, because it is believed that they are unique and have been the primary reason that improved densities have been obtained in Virginia during the last 6 years.

Virginia has used the control strip procedure and nuclear gauges to measure compaction on construction projects since 1966 (1,p.309). However, in the 1970s, with the Interstate system nearing completion, more and more plant mix was being used for maintenance overlays let to contract, and, for several reasons, no one method was used consistently to check densities on this work. A question arose about the adequacy of the compaction being attained, and an examination of the densities obtained for maintenance projects in 1975 and 1976 showed that only 16 percent met the specification then on the books but not widely applied (2). Consequently, an analysis was made of the specification to determine its severity, and a more realistic specification that contained pay factors based on performance criteria was developed. The new specification was first used in 1977 as a special provision for information only. In 1978 and 1979 it was used as a special provision