IMPACT OF VARIATION IN MATERIALS PROPERTIES ON ASPHALT PAVEMENT LIFE EVALUATION OF A QUESTIONNAIRE

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16. Abstract

In an effort to collect information on the status of quality control procedures and the use of pay adjustment factors, a questionnaire was distributed to all state agencies, the District of Columbia, and the Federal Highway Administration. Each agency was asked to respond to questions describing their current method for acceptance or rejection of asphalt concrete paving materials and related pay adjustment factors.

This report summarizes the results of the questionnaire. Analysis of results indicate:

1) Most state agencies will accept one or more property characteristics of asphalt concrete that are outside specification tolerances.
2) Most state agencies apply a pay adjustment factor to accepted materials which are outside specification tolerances.
3) Only 26 percent of the state agencies consider their pay factors to be proportional to reduced pavement serviceability.
4) Approximately one-half of the agencies consider the use of pay factor plans as effective in encouraging compliance with specifications.
5) There is a wide disparity in the pay adjustment factors used by the different agencies.

This is the first of several reports to be prepared in connection with this project.

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DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of either the Oregon Department of Transportation or the Federal Highway Administration.

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SUMMARY

In the fall of 1979, the Oregon State Highway Division and Oregon State University initiated a research project to study the impact of variations in material properties on asphalt pavement life due to an increase in the amount of pavement constructed in recent years with material outside of specification limits. The effect of this noncompliance on pavement serviceability has been questioned and has resulted in frequent controversy with contractors on the assessment of pay adjustments. This current study is aimed at developing a rational approach to assess the effects of variations from specification limits so a firm basis can be established for the development of pay factors.

In an effort to collect current information on the status of quality control procedures and the use of pay adjustment factors Oregon State University and the Oregon State Highway Division developed a questionnaire which was distributed to all state agencies, the District of Columbia, and the FHWA. Each state was asked to respond to seven questions with reference to their current method for acceptance or rejection of asphalt concrete paving materials. The items of emphasis on the questionnaire included:

1) acceptance of noncompliance construction and materials

2) properties tested and method of testing

3) pay adjustment factors used

4) basis for establishing pay factors

5) relationship of pay factors to pavement serviceability

6) effectiveness of pay factors

7) summary opinions regarding pay factors

This report summarizes the results of the questionnaire. Analysis of results indicates:

1) Almost all state agencies will accept one or more properties in the construction and materials of asphalt concrete that are outside specification tolerances.

2) Almost all agencies which accept construction and materials outside of specification tolerances apply a pay adjustment in compensating the contractor.

3) Only 26 percent of the agencies consider their pay factors to be proportional to reduced pavement serviceability.

4) Approximately one-half of the agencies consider the use of pay factor plans as effective in encouraging compliance with specifications.

This evaluation clearly illustrates the controversial nature of the concepts of accepting noncompliance construction and materials and the application of pay adjustment factors. It also points to a need for development of a rationale for these concepts which are based on sound engineering principles and equitable to all parties.

IMPACT OF VARIATION IN MATERIALS PROPERTIES ON ASPHALT PAVEMENT LIFE - EVALUATION OF A QUESTIONNAIRE

INTRODUCTION

In the fall of 1979, the Oregon State Highway Division and Oregon State University initiated a research project to study the impact of variations in material properties on asphalt pavement life.

This study is the result of the increased occurrence of pavement problems during recent years and in the proportion of pavements constructed with a significant amount of material outside of specification limits (1). The effect of this noncompliance on pavement serviceability has been questioned and has resulted in frequent controversy with contractors on the assessment of pay adjustments which generally result in reduced pay to the contractor for material which is determined to be outside the specification tolerances. The current study is aimed at developing a rational approach to assess the effects of variations from specification limits so a firm basis can be established for the development of pay factors.

The AASHO Road Test (1958-60) emphasized to the highway industry the significance of the relationship of the variability of material test properties to highway specifications (2). As a result agencies have

been developing and experimenting with various combinations of statistically based specifications to provide a more accurate evaluation of the end products and to allow acceptance of noncompliance work in conjunction with a reduced payment for that work. In 1976, thirty-three states were using or had tried some form of statistically oriented end-result specifications (3).

In an effort to collect current information on the status of quality control procedures and the use of pay adjustment factors, Oregon State University, and the Oregon State Highway Division developed a questionnaire which was distributed to all state agencies, the District of Columbia, and the Federal Highway Administration in November, 1979. Questionnaires were returned by all except four states, resulting in a 92 percent response rate. Each state was asked to respond to seven questions with reference to their current method for acceptance or rejection of asphalt concrete paving materials. A copy of the questionnaire is included in Appendix A. The items of emphasis on the questionnaire included:

1) acceptance of noncompliance construction and materials with or without pay adjustments
2) identification of properties tested for acceptance and the method of test used.
3) pay adjustment factors used in relation to each tested property
4) rationale used in establishing pay adjustment factors
5) relationship of pay adjustment factors to pavement serviceability or other criteria
6) effectiveness of pay adjustment factors in encouraging com-

pliance with specifications

7) summary opinions regarding the use of pay adjustments.

While the required information could be placed on the questionnaire itself, the states were encouraged to include copies of supplemental information which would assist in the overall evaluation. Most states did provide supplemental materials.

The returned questionnaires were carefully evaluated and the information tabulated as shown in Appendix B. In the cases where no specific answers were given for the questions, the author interpreted the supplementary information provided to arrive at specific answers. This procedure was most prevalent in identifying the test method used for evaluating each property, since many states allow the use of more than one test method in their specifications.

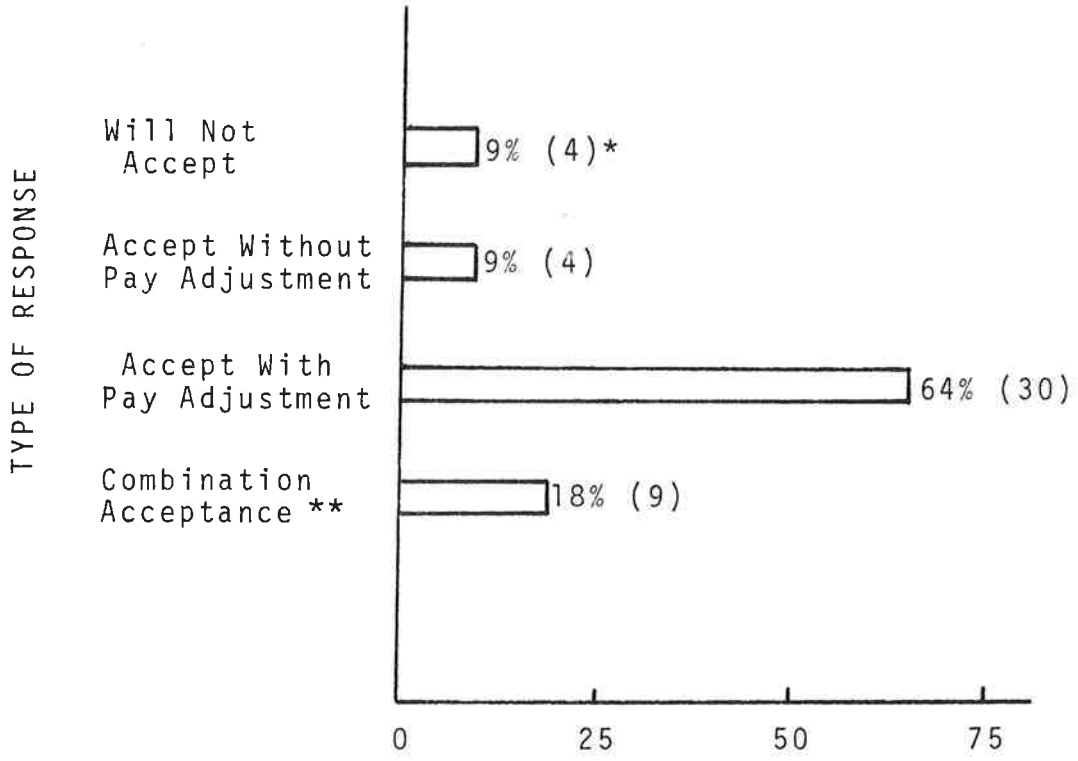
EVALUATION OF QUESTIONNAIRE RESULTS

Question 1

"Do you accept asphalt concrete pavement construction and materials that do not satisfy specification requirements?"

The responses to this question are summarized in Figure 1. Of the 47 agencies which responded, only four agencies indicated that they will not accept construction work or materials which are below specification. All the remaining agencies (91 percent) will accept some aspects of the work or materials when they are below specification.

The key concept illustrated is that 82 percent of the agencies use some form of pay adjustment factors when accepting one or more of the evaluated criteria. However, only four states indicated a pos-



* Number in parentheses is number of agencies

** Acceptance of some deficient materials with pay adjustment and other deficient materials without pay adjustment.

Figure 1 : Acceptance of Construction Work and Materials That do not Satisfy Specification Requirements

sible acceptance of below specification work or materials on every evaluated property considered in the questionnaire. All other agencies identified certain criteria which would not be accepted if below specification limits. A detailed discussion of these criteria will be included in the analysis of Questions 2 and 3 of the questionnaire. The 18 percent labeled "combination acceptance" indicate agencies which will accept some deficient materials with pay adjustment and other deficient materials without pay adjustment.

Question 2

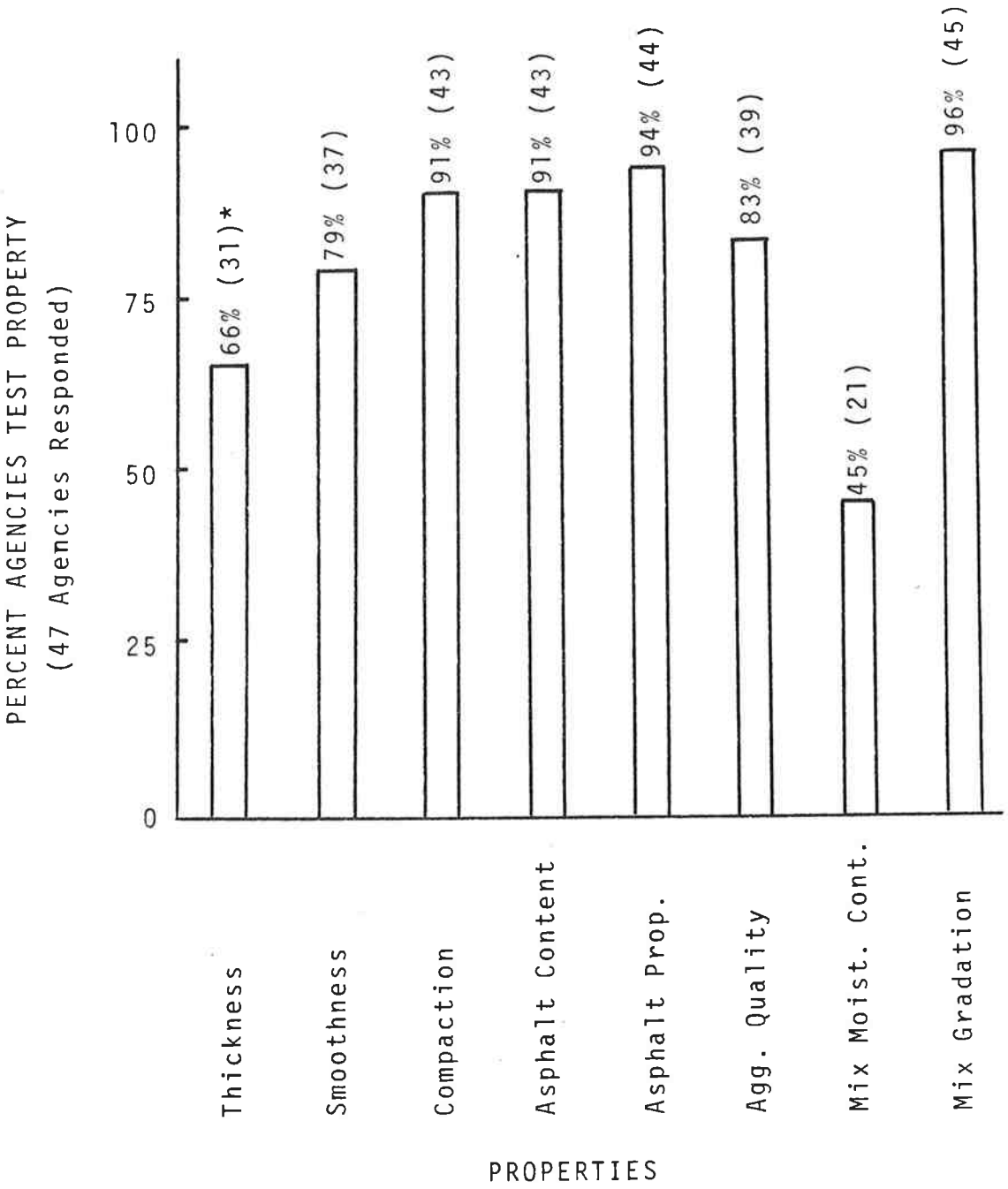
"What properties do you evaluate to establish the acceptability of an asphaltic pavement?"

The questionnaire listed eight properties commonly evaluated during or at the completion of construction. These properties were thickness, smoothness, compaction, asphaltic content, asphalt properties, aggregate quality, mix moisture content, and mix gradation. Each agency was asked to identify which properties are evaluated and controlled by their specifications and to indicate the method of testing used. Figure 2 summarizes the data received concerning which properties are evaluated. The data for the method of testing will be discussed in conjunction with Question 3 dealing with the use of pay factors. All property criteria except the mix moisture content are evaluated by at least two-thirds of the agencies.

Question 3

"What are your pay adjustment factors for each of the properties identified in Question 2?"

The data summaries relating to pay adjustment factors and



* Number in parentheses is number of agencies

Figure 2 : Properties Tested to Evaluate the Acceptability of an Asphaltic Pavement

methods of testing are shown in Figures 3 through 10. Each figure depicts a different property and will be discussed individually.

The information on the method of test was collected as part of Question 2. Most agencies indicated the use of a specific test method for each property being evaluated. In the cases where a test method was not identified, the author interpreted the data provided, usually a copy of that agency's specifications, to arrive at specific answers for use in the data evaluation. Where agencies indicated the acceptance of several methods of testing, the method most commonly used by other agencies was selected for presentation. Reference to AASHTO test methods in the following discussion also includes the various modifications of AASHTO procedures.

The basis of applying pay factors was broken into five categories. These are identified as follows:

1) Statistical. The concepts of random sampling are used in collecting test data. The statistical methods employed to evaluate the measurements include the use of simple averaging, the range of measurements, the normal distribution, and the Students t distribution (3).

2) Guide in Specification. The agency makes use of a pay adjustment factors guide, usually in tabular form, which is part of the specification in which statistical methods are not used.

3) Schedule - Not in Specification. The agency has established guidelines for use in applying pay factors, but they are not a part of the specifications. For example, South Dakota

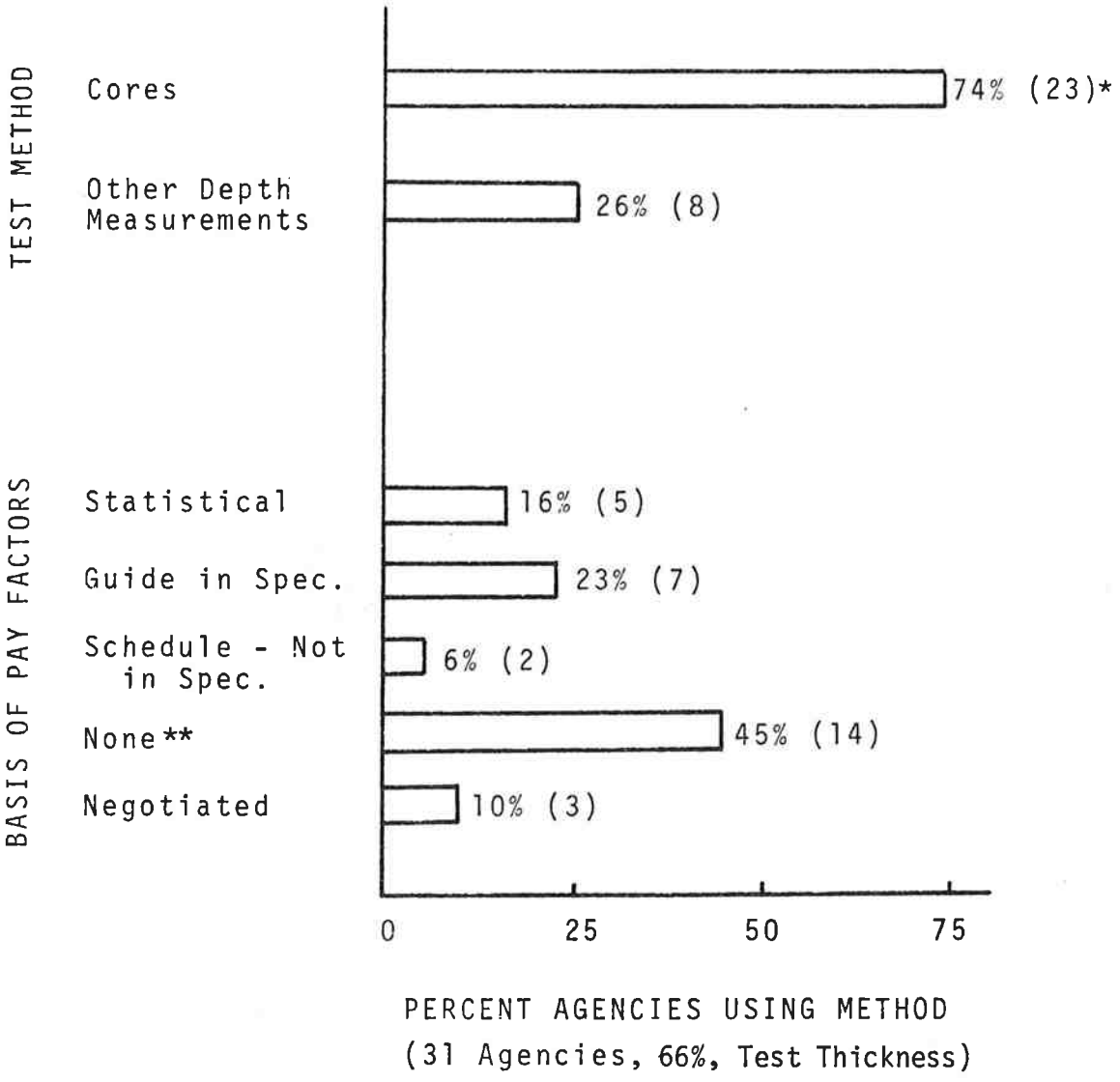
has a "Price Adjustment Committee" which determines pay adjustments for each case individually. The state has a guide of pay factors which may be used at the committee's discretion.

4. None. Materials below specification are not accepted, thus no pay factors are involved.
5. Negotiated. The agency accepts below specification work and materials based on negotiations with the contractor. These negotiations include pay adjustment.

It is important to note that many of the agencies which make use of pay adjustment factors still retain a process of decision making by the agencies project engineer. The pay factors are applied only if the below specification work or material is accepted.

Thickness: Figure 3 summarizes the questionnaire information for thickness evaluation. Thirty-one agencies evaluate the thickness of the finished pavement with 74 percent of this total using cores for measurement of the final thickness. The remaining agencies use other methods such as measuring the uncompacted thickness at the paver and applying a predetermined coefficient based on density to determine final thickness. It is likely that all state agencies monitor this property even though they do not use it in their pay criteria.

Almost half of the agencies will not accept a pavement thickness which is below specification tolerances. Most of these agencies specify that an overlay is required to bring the thickness up to specification with all costs borne by the contractor. The remaining agencies accept final thicknesses which are below specification



* Number in parentheses is number of agencies
** Materials below specifications are not accepted

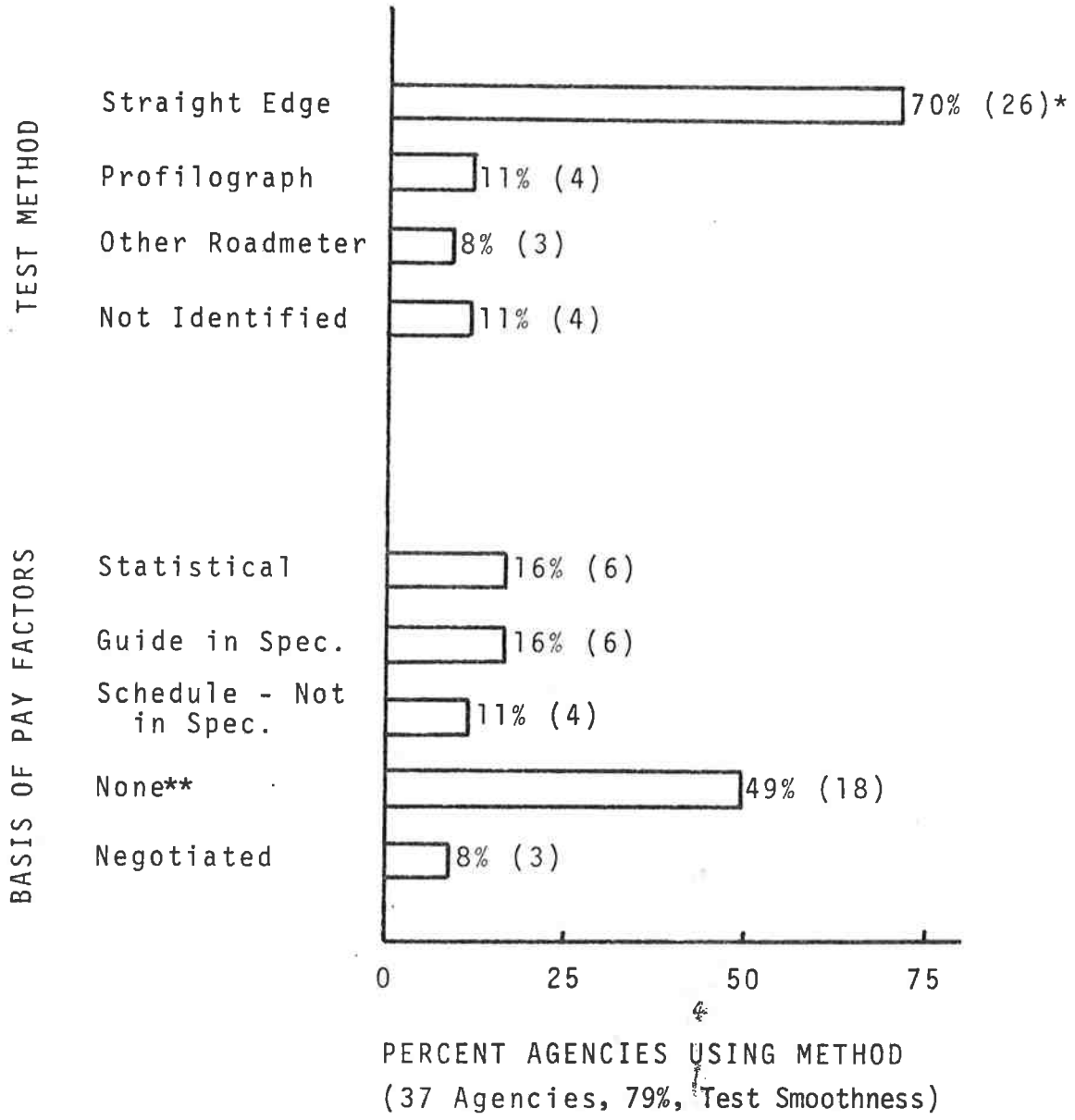
Figure 3 : Requirements for Thickness of Pavement

in conjunction with some form of pay adjustment.

Smoothness: Figure 4 shows the data summary from the questionnaire regarding smoothness. Seventy-nine percent of the agencies evaluated the smoothness of the finished pavement surface. Of these agencies, 70 percent use the straight edge as the basis of their measurements. While 11 percent did not identify a method of testing, the remaining 19 percent use various roadmeters, such as the profilograph and the PCA Roadmeter.

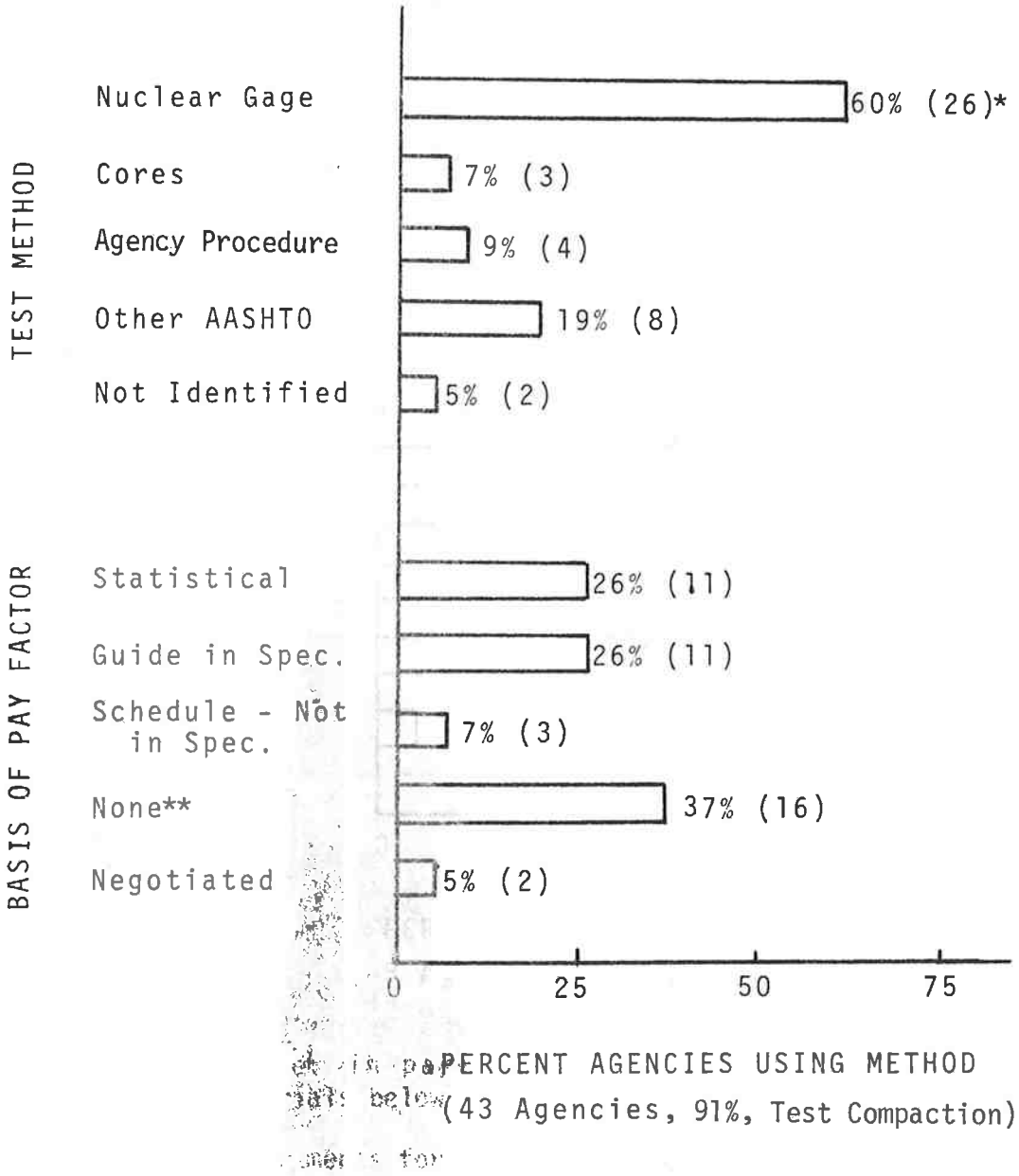
Similar to the thickness evaluations, approximately one-half of the agencies accept pavements which do not meet the smoothness specification tolerances. Most of these apply a pay adjustment factor to account for the increased maintenance requirements. The other half of the agencies will not accept pavement surfaces which are outside the tolerance limits; but most of them allow a contractor to bring the surface up to specification with placement of an overlay at the contractor's expense.

Compaction: The results of the questionnaire data relating to compaction are shown in Figure 5. Of the 43 agencies which evaluate compaction, 60 percent use nuclear gage test methods, such as AASHTO T-238. The seven percent using cores, indicated use of AASHTO T-230 as a standard. The other AASHTO methods specified by 19 percent of the agencies were T-209, used to determine maximum specific gravity, and T-166, used to determine bulk specific gravity. The nine percent using their own procedural specification gave detailed procedures of the test requirements without reference to any of the standard test methods.



* Number in parentheses is number of agencies
** Materials below specification are not accepted

Figure 4 : Requirements for Smoothness of Pavement



* Number in parentheses is number of agencies
** Materials below specification are not accepted

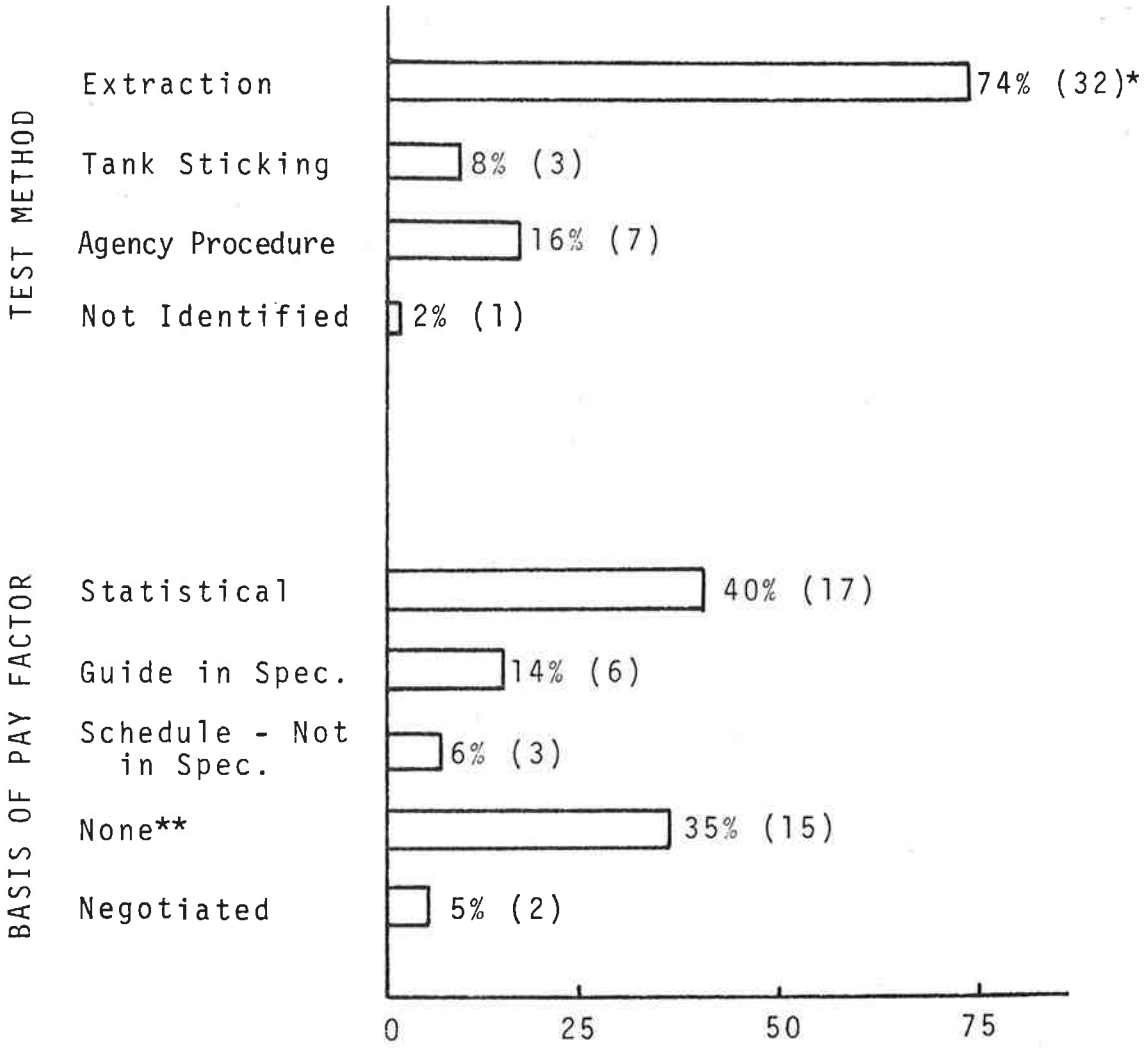
Figure 5 : Requirements for Compaction

Almost two-thirds of the agencies accept pavement sections which have not been compacted to specification requirements. The other 37 percent of the agencies indicated they would not accept pavement which was improperly compacted; however, the available information was insufficient to identify procedures used to remedy the deficiency.

Asphalt content: Figure 6 shows the summary of the testing methods used and the basis for pay adjustment factors applied when accepting below specification material. Ninety-one percent of the agencies evaluate the asphalt content with three-fourths using an extraction method such as AASHTO T-164. The remaining agencies use other methods such as tank sticking.

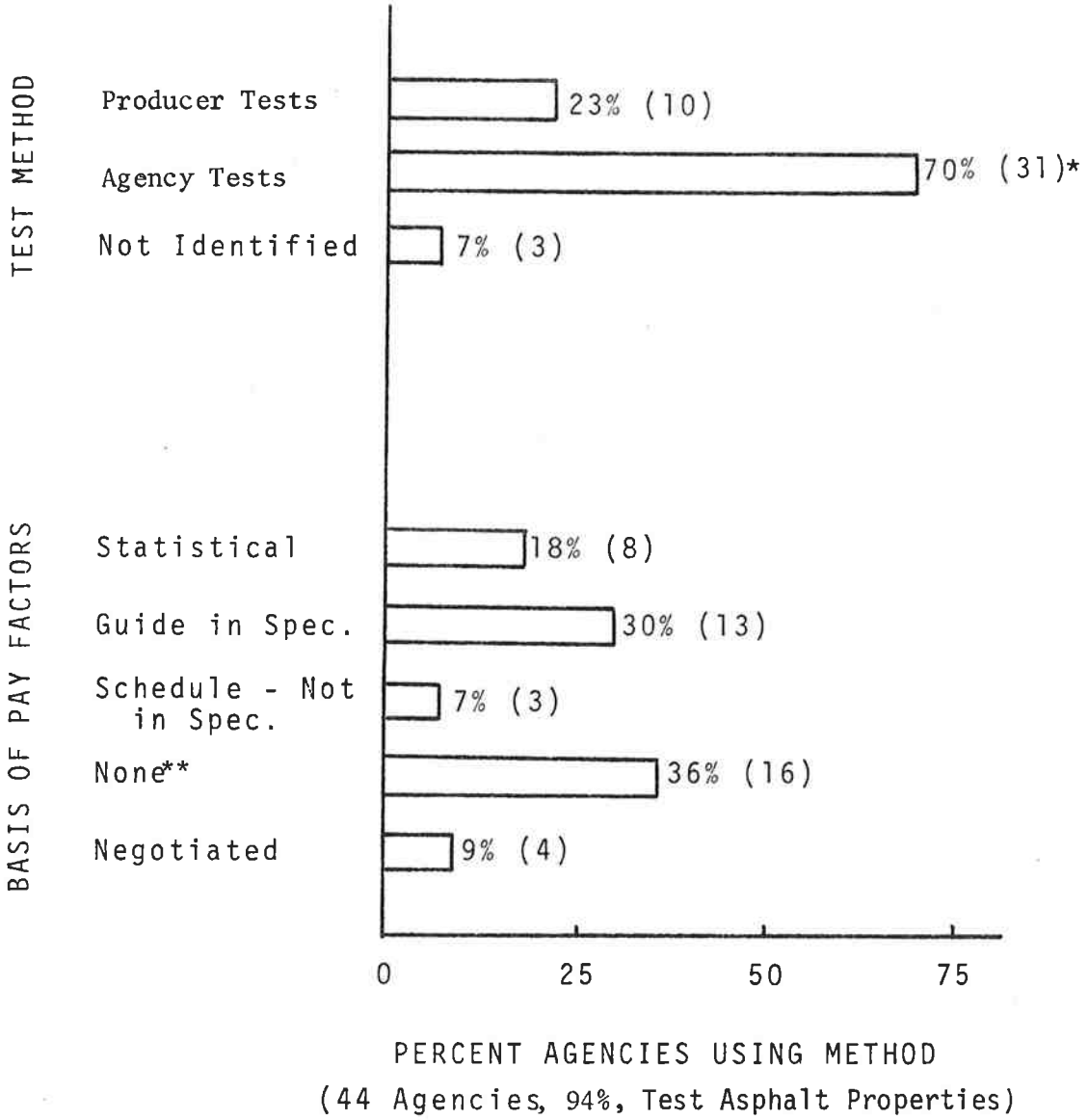
Approximately one-third of the agencies will not accept material which is outside the tolerance limits of the specifications. Most of those agencies check the asphalt content on a regular basis during construction so that adjustments can be readily made without great losses of time or materials. Therefore, pay adjustments are not needed. The majority of the agencies will accept materials with asphalt content below specification tolerances. The most commonly used basis for pay adjustment factors by these agencies is statistical in nature.

Asphalt Properties: Forty-four agencies or 94 percent of those responding to the questionnaire provide for the evaluation of the asphalt properties in their specifications. A summary of test methods and pay adjustment factors used by these agencies is shown in Figure 7. The majority (70 percent) of the agencies use a combination of various



* Number in parentheses is number of agencies
** Materials below specification are not accepted

Figure 6 : Requirements for Asphalt Content



* Number in parentheses is number of agencies
** Materials below specification are not accepted

Figure 7 : Requirements for Asphalt Properties

AASHTO test methods to evaluate the individual characteristics of the asphalt. AASHTO tests and specifications used by one or more agencies include the following:

T-40 Sampling of Bituminous Materials

T-44 Solubility of Bituminous Materials in Organic Solvents

T-48 Flash and Fire Points by Cleveland Open Cup

T-49 Penetration of Bituminous Materials

T-51 Ductility of Bituminous Materials

T-73 Flash Point by Pensky-Martens Closed Tester

T-179 Effect of Heat and Air on Asphalt Materials - Thin Film Oven Test

T-201 Kinematic Viscosity of Asphalts

T-202 Absolute Viscosity of Asphalts

M-20 Penetration Graded Asphalt Cement

M-226 Viscosity Graded Asphalt Cement

The remaining agencies base their acceptance of asphalt on quality assurance reports prepared by the producer. While specific test methods are not indicated, use of AASHTO test methods by the producers would also be anticipated.

Slightly over one-third of the agencies will not accept asphalt with properties which do not meet the specification tolerances. These agencies evaluate the asphalt properties before use in material mixes; thus, unacceptable asphalt can be rejected with little loss of time or money. The remaining two-thirds of the agencies will accept asphalt with properties which do not meet specification tolerances. The ma-

jority of these have a pay factor guide included in their specifications, but only 18 percent base their pay factors on statistical concepts. Available data was insufficient to determine if any agencies test after incorporation in the mix to check for asphalt contamination.

Aggregate Quality: Eighty-three percent of the agencies responding provide for evaluation of the aggregate quality in their specifications. Several agencies indicated that they do not evaluate the aggregate quality as part of the contractor's specifications because the aggregate source has been approved by the state. Figure 8 shows the data summary for test methods and basis of pay factors currently used for aggregate quality. Of those agencies evaluating the aggregate quality, 72 percent make use of the AASHTO test procedures. The predominate test specified is AASHTO T-96 which measures resistance to abrasion by use of the Los Angeles machine. Other AASHTO test methods specified by one or more agencies include:

T-27 Sieve Analysis of Fine and Course Aggregates

T-84 Specific Gravity and Absorption of Fine Aggregate

T-89 Determining Liquid Limit of Soils

T-90 Determining Plastic Limit and Plastic Index of Soils

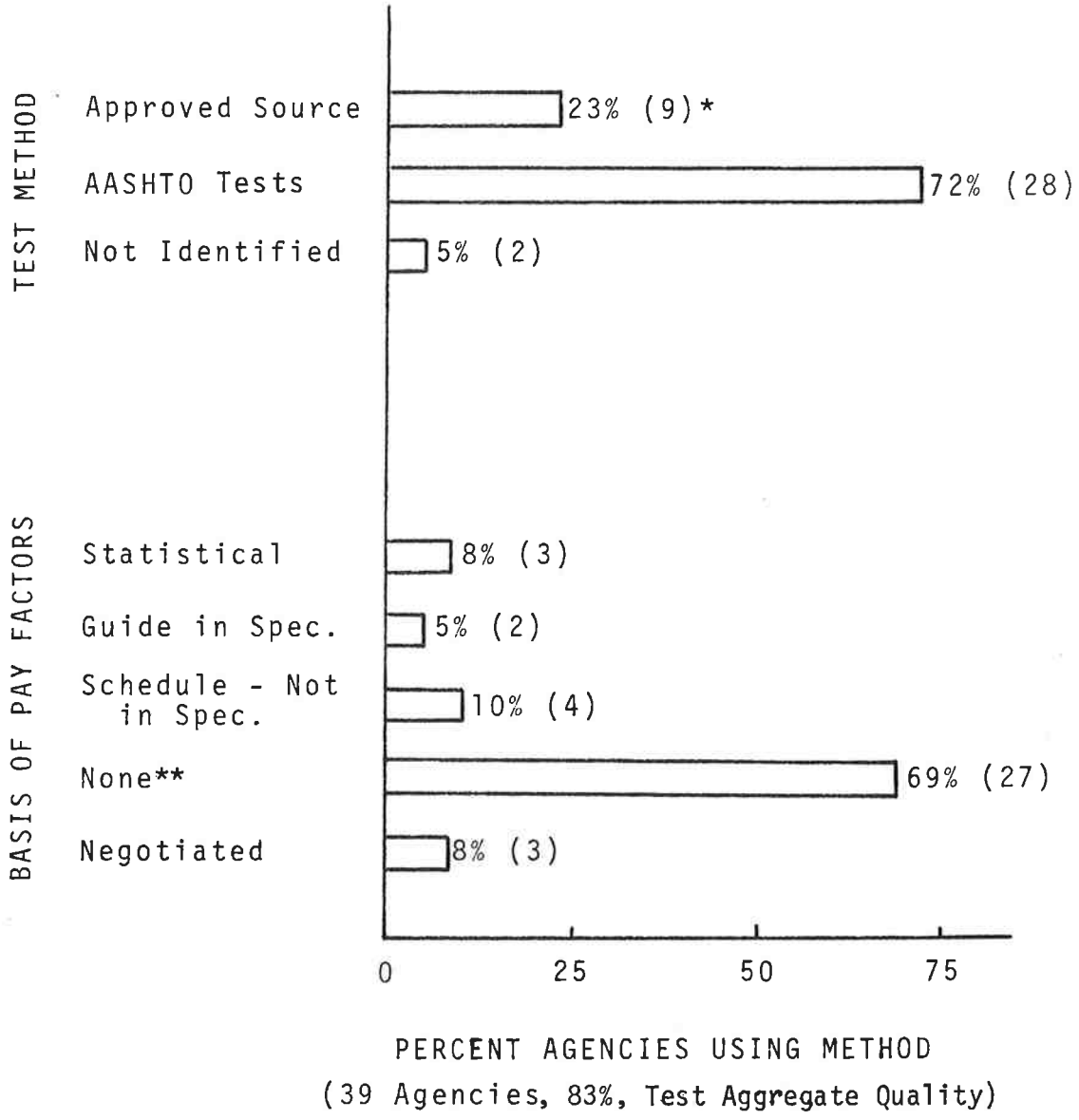
T-103 Soundness of Aggregates by Freezing and Thawing

T-104 Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate

T-176 Plastic Fines in Graded Aggregate by Use of Sand Equivalent Test

T-182 Coating and Stripping of Bitumen-Aggregate Mixtures

T-210 Production of Plastic Fines in Aggregates



* Number in parentheses is number of agencies
** Materials below specification are not accepted

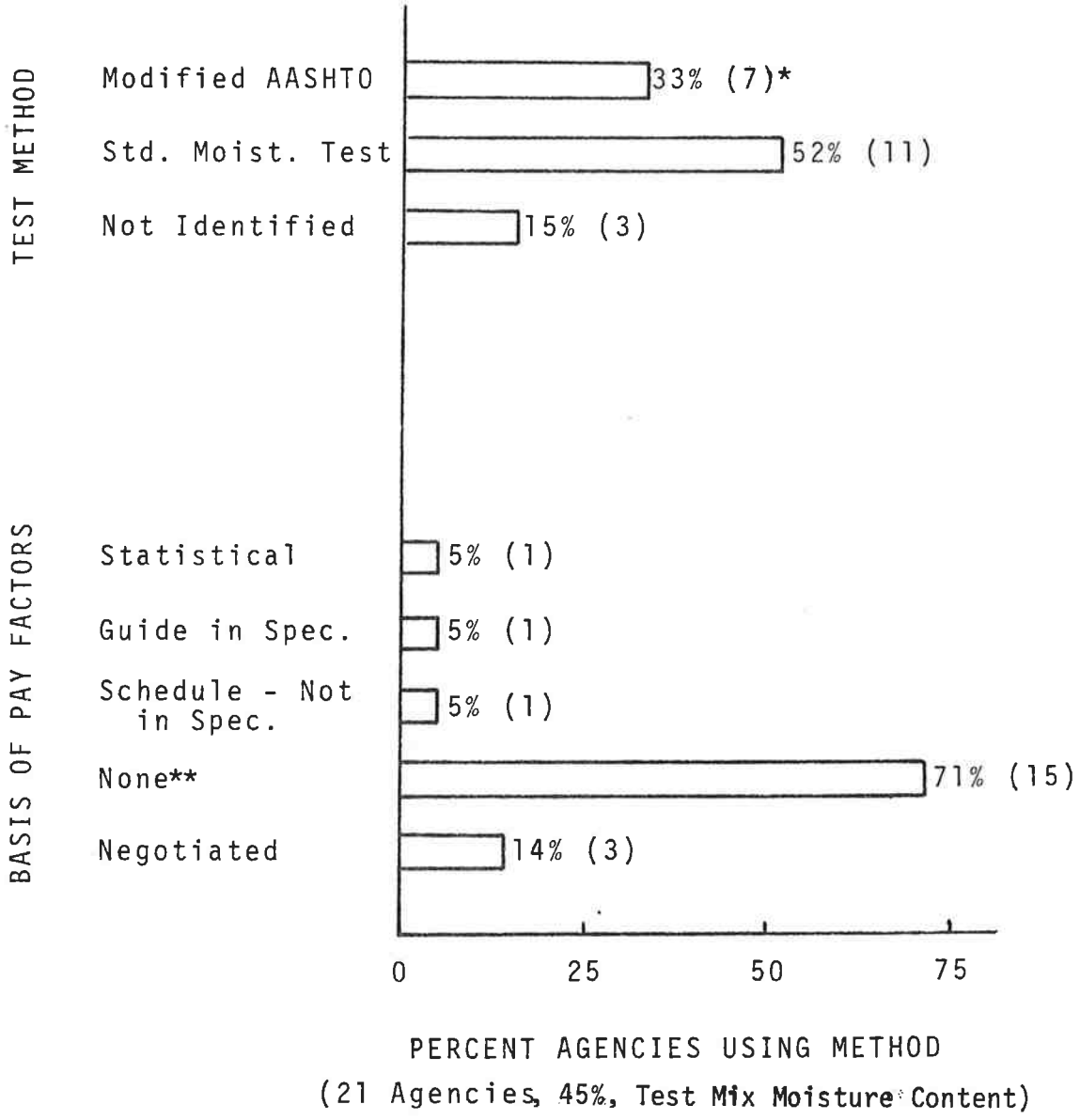
Figure 8 : Requirements for Aggregate Quality

Most of the agencies which do not specify AASHTO test methods indicated their acceptance was based on information from previously approved aggregate sources. It would be reasonable to assume that some form of AASHTO test method was used by most agencies when originally approving the aggregate sources.

Over two-thirds of the agencies do not accept aggregate which is below specification quality. Since most testing is achieved prior to delivery of material to the construction site, there is seldom a need to accept inferior aggregate. For the few situations where below specification aggregate is accepted, there is no dominant method of developing pay adjustment factors.

Mix Moisture Content: Less than half (45 percent) of the agencies evaluate the mix moisture content as part of their specifications. The test methods and the basis for pay factors used by these agencies are summarized in Figure 9. Very little information relating to the test methods was given on the questionnaire responses for this property. Most of the agencies simply indicated the use of standard moisture tests. Those which specified a particular test referred to AASHTO T-110.

Of the agencies using mix moisture content as a specification criterion, 71 percent will not accept material outside the tolerance limits of the specification. This is a property which can be controlled during the construction process often with little loss in time or materials, thus no pay adjustments are necessary. For the few



* Number in parentheses is number of agencies
** Materials below specification are not accepted

Figure 9 : Requirement for Mix Moisture Content

situations where below specification materials are accepted, there is no dominant method of developing pay adjustment factors.

Mix Gradation: All but two of the 47 agencies which responded evaluate mix gradation (aggregate gradation within mix) as part of their acceptance criteria. Figure 10 shows a summary of the questionnaire results concerning the test methods and basis for pay factors used in evaluating the mix gradation. AASHTO test methods specified include:

T-11 Amount of Material Finer than 0.075 mm Sieve in Aggregate

T-27 Sieve Analysis of Fine and Coarse Aggregates

T-30 Mechanical Analysis of Extracted Aggregate

T-37 Sieve Analysis of Mineral Filler

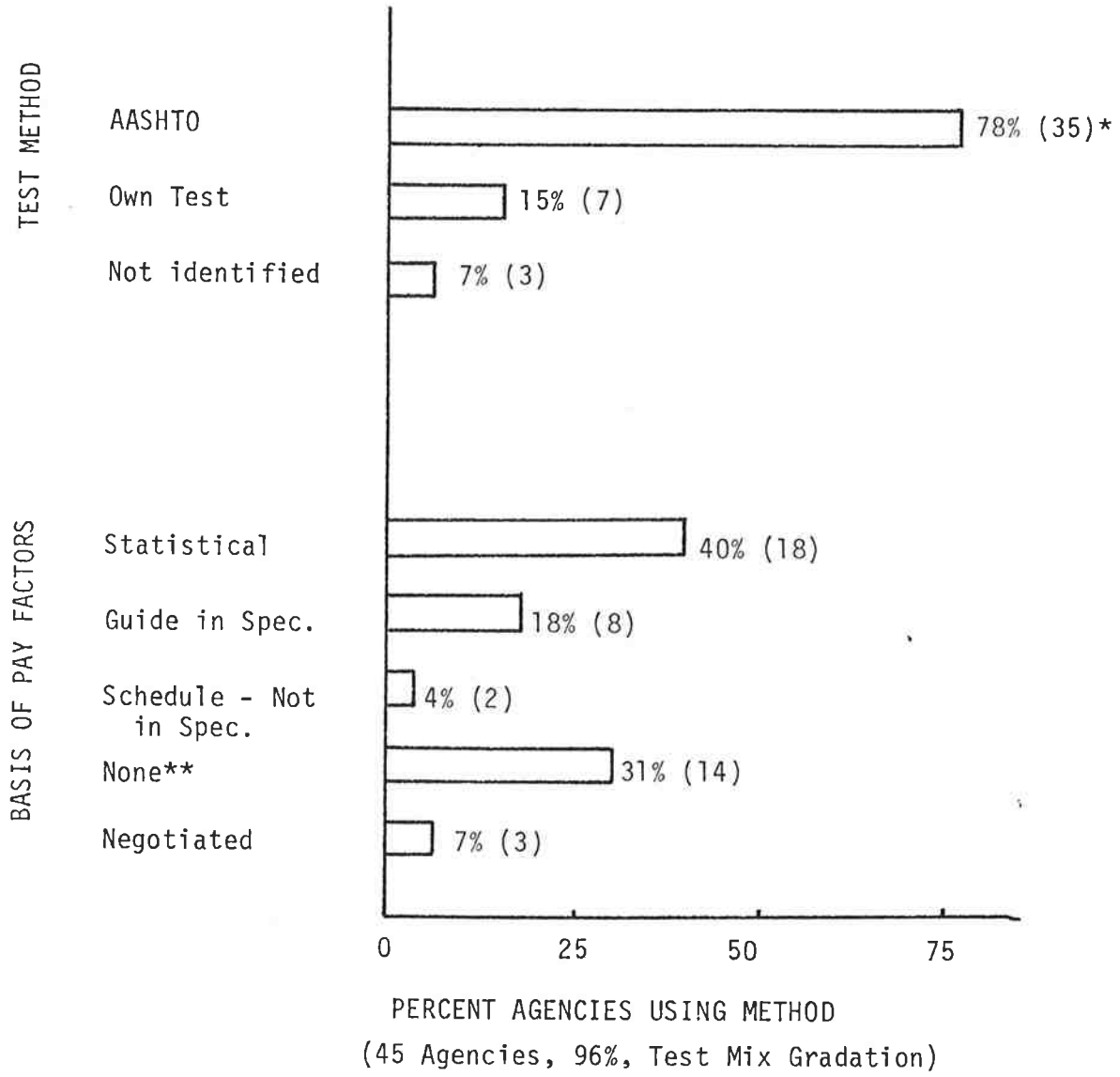
T-164 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

Specific sieve requirements vary from state to state but the most commonly evaluated sizes are the 3/8, No. 4, No. 8, and No. 200.

Slightly over two-thirds of the agencies accept mixes with a gradation that does not satisfy specification tolerances. Of these, the majority base their pay adjustment factors on statistical concepts. The 31 percent which will not accept below specification mixes indicated control of the gradation during material preparation. This allows rejection and modification of mixes on a continuing basis resulting in small losses of time or material. Therefore, no pay factors are necessary.

Question 4

"How were your pay adjustment factors established?" This question was used in an effort to identify the background



* Number in parentheses is number of agencies
** Materials below specification are not accepted

Figure 10 : Requirements for Gradation of Mix

for justification and development of pay adjustment factors. The four categories listed were laboratory results, field studies, experience, and other. Each agency indicated which categories they relied on in accepting below specification work or materials and determining the pay adjustments. The data shown in Figure 11 summarizes the background characteristics used by the various agencies in their specification development.

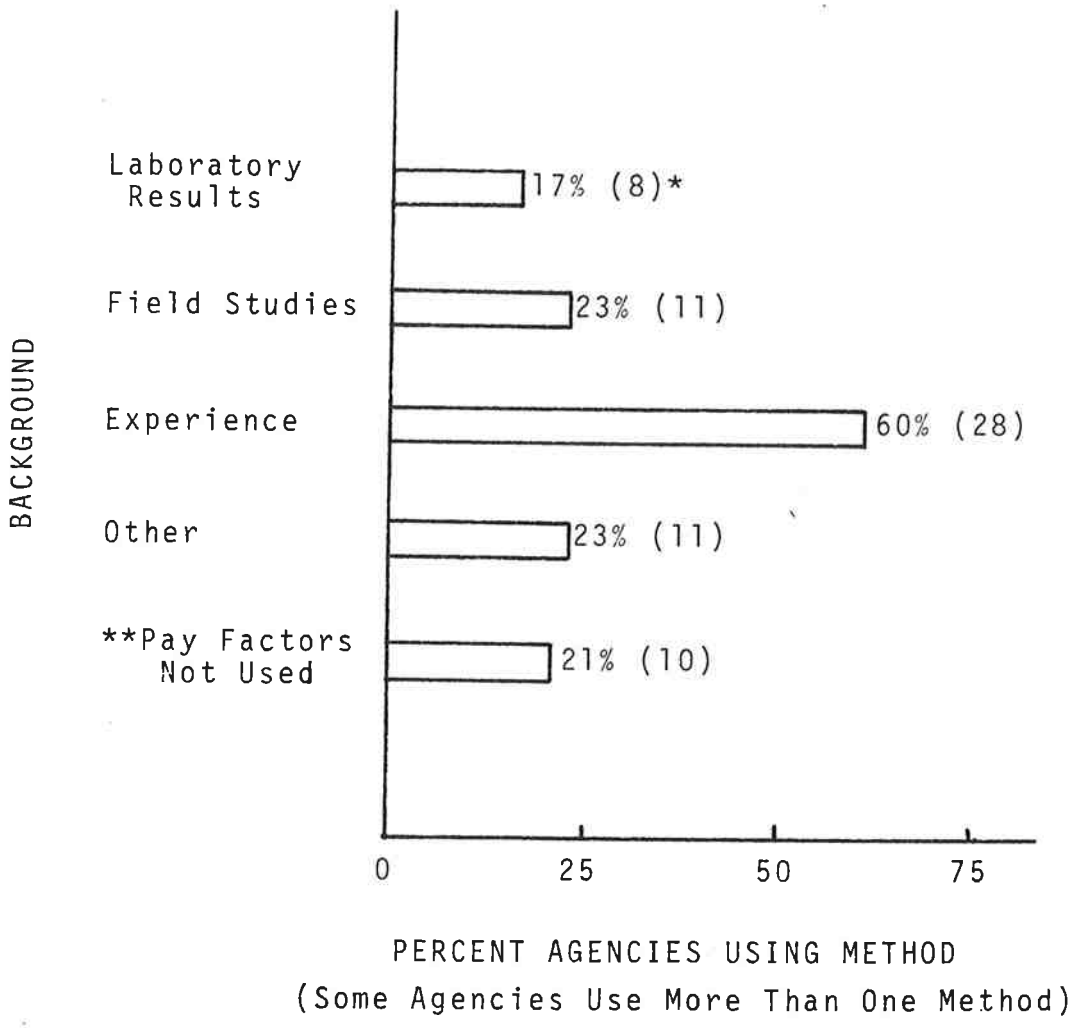
Experience is the predominant background relied upon in the development of pay factors as indicated by 60 percent of the agencies. The remaining background categories are used almost equally by the agencies. Since several agencies have relied on more than one background category, the total percentage is greater than 100 percent.

Also note that a fifth category is added to the results in Figure 11 to account for those agencies which do not use pay factors. The 21 percent shown includes the four agencies which will not accept anything below specification and the six agencies which occassionally accept one or more properties, which are below specification, on a negotiated basis.

Question 5

"Is your pay adjustment proportional to the value of reduced pavement serviceability resulting from specification noncompliance?"

This question, as well as Questions 6 and 7, requires the person responding to the questionnaire to express an opinion on behalf of that agency. It is important to note that the response from an agency may be a function of who answered the questionnarie, i.e., opinions will vary within an agency. Therefore, the corresponding data and figures should not be considered as absolute agency policy; but should



* Number in parentheses is number of agencies

** Six of these occasionally have adjusted payment on negotiated basis and four do not accept out of specification materials.

Figure 11 : Predominant Method for Establishing Pay Factors

be considered as valuable indicators of current trends in the development and use of pay factors.

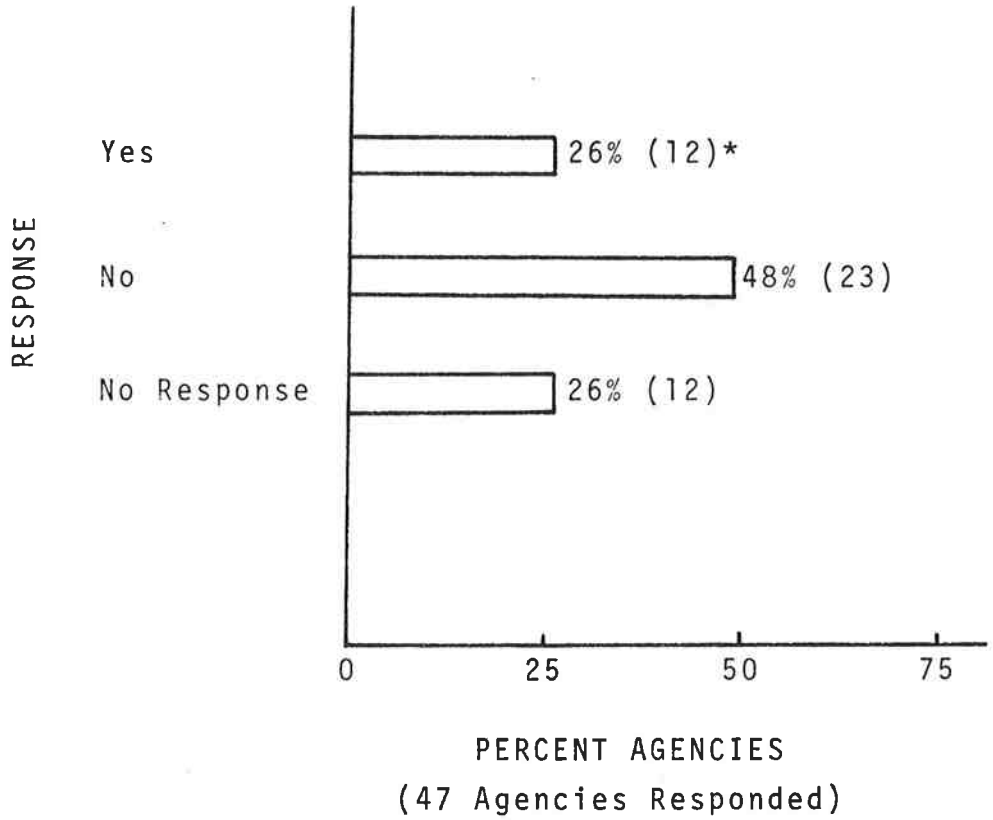
Figure 12 presents a summary to the first part regarding the relationship to pay factors and pavement serviceability. Only 26 percent of the agencies indicated that they believed their pay adjustments are proportional to reduced pavement serviceability. In addition, several of those agencies indicated that they used engineering judgement and experience to develop that rationale and they could not verify it in terms of engineering principles. Forty-eight percent of the agencies identify no relationship between their pay factors and pavement serviceability and the remaining 26 percent did not respond to this question.

Figure 13 gives a summary of the responses to the second part of this question identifying rationale other than serviceability for establishing pay adjustment factors. The 23 agencies who responded with a "no" on the first question gave six different rationales for determining their specific pay factors. Thirty percent use pay factors in their specifications to discourage noncompliance. Another 22 percent are following recommendations made by FHWA in its model specification presented approximately ten years ago in conjunction with a study on statistically based specifications. This model does not appear to have been formally published, but FHWA specification FP-79 is essentially an updated version of that model specification (4).

Question 6

"Do you feel your pay adjustment factors are effective in encouraging compliance with specifications?"

The response to this question is summarized in Figure 14. Slightly more than half of the agencies indicated they felt their pay adjustment



* Number in parentheses is number of agencies

Figure 12 : Pay Adjustment Proportional to Reduced Pavement Serviceability

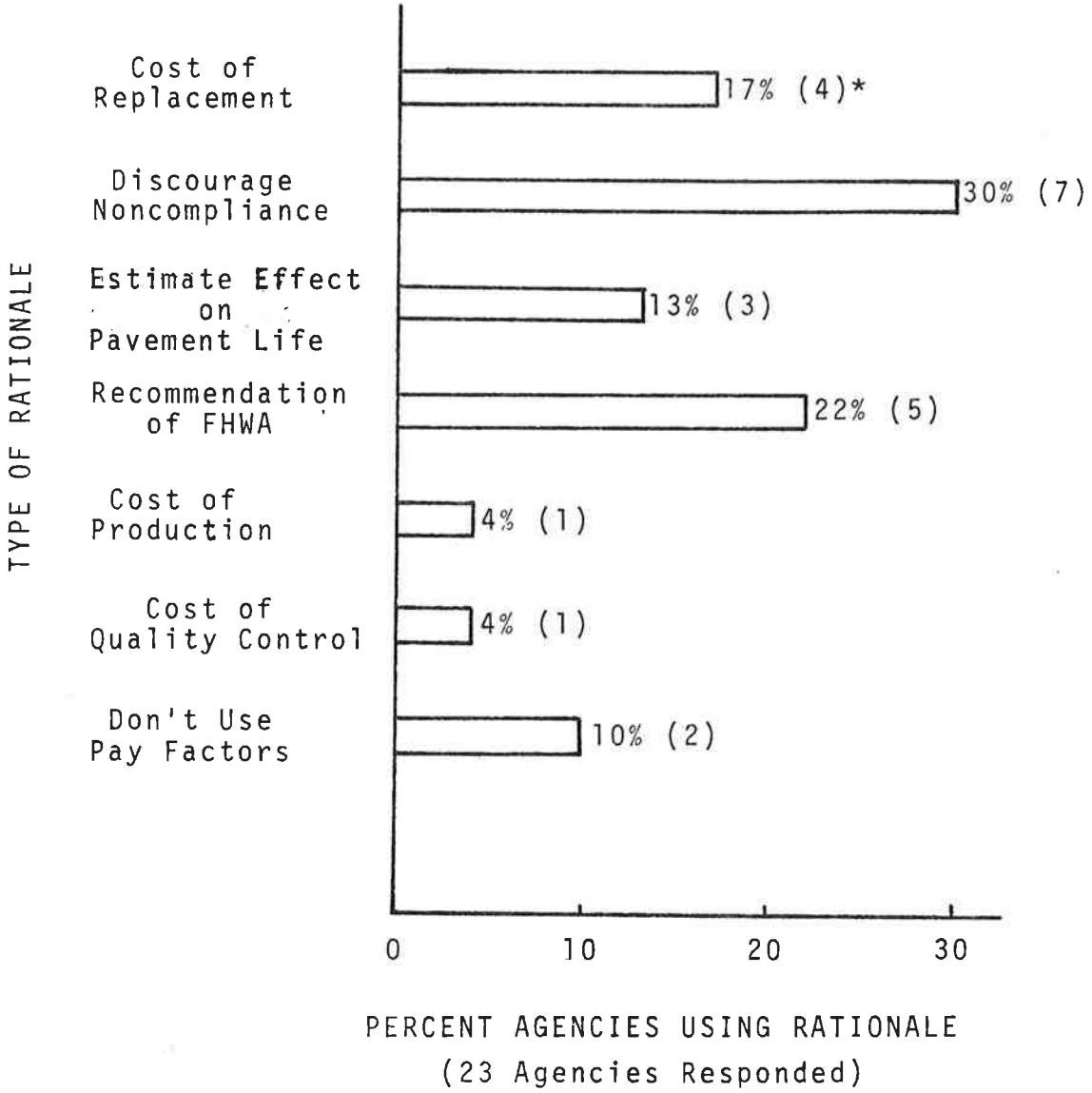


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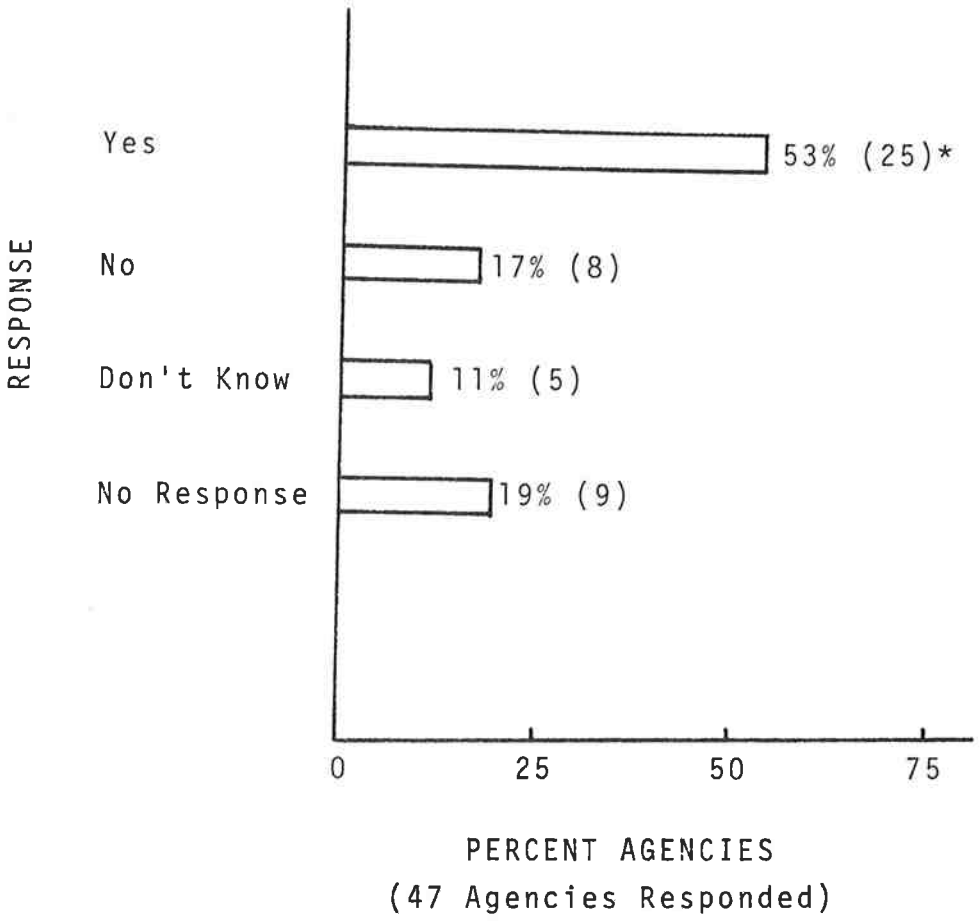
Figure 13 : Rationale Other than Serviceability for Determining Pay Factors



* Number in parentheses is number of agencies

Figure 14 : Pay Factors are Effective

factors are effective and an additional 30 percent which are uncertain about their effectiveness.

Question 7:

"Summarize your opinion regarding the need for pay adjustments or the success of your method for acceptance of paving materials."

The responses to this portion of the questionnaire were edited for conciseness and are presented in Table B-2 in Appendix B. The opinions given cover the full spectrum from "don't believe in pay factors" to "end-result specifications are the way to go." The wide range of positive and negative comments, with few agencies concurring, illustrates the controversial nature of this topic. There is a need to develop a rationale which is consistent with sound engineering principles, acceptable to a majority of the agencies, and equitable to all parties. Some of the advantages and disadvantages regarding the need for pay adjustments are listed below.

Advantages

- contractors improve quality control
- creates a uniform procedure for accepting non-compliance work
- reduces problems of contract administration
- reduces litigation
- pay adjustment method requires fewer state personnel

Disadvantages

- needs to be based on sound engineering approaches
- contractors resist
- contractors may increase bids
- results in poor quality work
- can't measure reduced serviceability
- administration problems

SPECIFIED PAY ADJUSTMENT FACTORS

In response to Question 3 on the questionnaire, each agency was asked to identify pay adjustment factors for the eight properties listed. A majority of the states included either a tabulation of their current pay factors or partial sections from their specifications. The state agencies which provided specific pay adjustment factor information are listed in Table 1. This table also indicates the specific properties to which the pay factors are applied. Note that although some agencies indicated use of pay factors for aggregate quality and mix moisture content, no information on those pay factors was submitted. Details of the pay adjustment factors are given in Appendix C and are summarized in the folloiwng discussion. While these data are useful in identifying current trends in the use of pay adjustment factors, it is not complete since some state agencies did not submit detailed information.

General Considerations

There are several general considerations which affect the application of pay adjustment factors regardless of the property being evaluated. These are the lot size, the identification of contract pay items affected by pay adjustments and the effects of multiplicative relationships of pay adjustments.

Throughout the sampling and testing process, the assumption is made that the selected samples taken are representative of a larger amount of material. This is based on the use of random sampling techniques. It is important that the size of this lot be specified as part of the overall acceptance plan.

An evaluation of the specifications made available through this

Table 1: Pay Adjustment Factor Information Provided by State Agencies

	Compaction	Asphalt Content	Mix Gradation	Thickness	Smoothness	Asphalt Properties
Alaska	X	X	X			
Arizona		X	X			X
Colorado	X	X	X			
Connecticut	X	X	X			X
Florida	X	X	X		X	X
Georgia	X	X	X			
Hawaii	X					
Illinois	X	X	X	X		
Indiana	X	X	X		X	
Iowa	X	X	X	X		X
Kentucky		X	X			X
Louisiana	X		X		X	X
Maryland		X				
Minnesota	X	X				
Mississippi	X	X	X			
Nebraska	X	X	X			
New Jersey	X	X	X	X	X	
New Mexico		X	X			X
New York	X					
North Dakota	X	X	X			
Ohio		X	X			
Oregon	X	X	X			X
Pennsylvania	X	X				
South Carolina		X	X			
South Dakota	X	X	X			
Utah	X	X	X			
Vermont	X				X	X
Virginia		X	X			
Washington	X		X			X
West Virginia	X	X	X		X	
Wyoming						X

questionnaire shows that there are four types of lot criteria typically used. Very few agencies use the same lot size even when they specify the same type of lot.

These lot types and typical size specifications are:

1) Tons of asphalt - normal lot size varies from 150 tons to 3,000 tons.
2) Full days production - Normal lot shall consist of the number of tons produced and placed each production day or within one shift.
3) Square yards of Pavement Surface - Normal lot size varies from 1800 sq. yd. to 6700 sq. yd.
4) Lineal feet of paving lane - Normal lot size varies but is identified as the amount of pavement placed at the time of testing, up to 5000 lineal feet.

Some agencies include options for two or more of these lot types within their specification. For example, Alaska's Supplemental Specification 401 - 402 states:

> "A normal lot will be 2,500 tons, except when the total for the project is less than the normal lot. Then the project total will consititute a lot. In addition there will be an allowance of 100 tons at the initial start of a project on which no price adjustment will be computed or applied and the material will be accepted on the basis of substantial conformity. This will allow for the natural variations in the beginning of production."

Illinois has a Special Provision revised as of March 15, 1979, which supercedes Section 406 of the Standard Specifications. In part this document states:

> "A lot shall consist of one day's production. In the event, however, that the contractor requests, a lot may be defined in terms of tonages; 1000 tons minimum to 3000 tons maximum, the exact amount to be agreed upon between the contractor and the Engineer prior to the start of work."

The most common pay item is "asphaltic concrete" with a unit price

per ton. The specifications also typically indicate that this bid item shall be full compensation for furnishing and placing all materials including asphalt cement and for all approved additives, for all preparation of surfaces, for all hauling, mixing, spreading, rolling, and all other operations necessary to complete the contract item. On projects bid in this manner, pay factors resulting from noncompliance of one or more material characteristics are applied to this one item. A detailed explanation of the application of pay factors to the bid items is given in the following paragraphs.

Several states indicate that on some projects the bid items are modified to include a specific item for the asphalt properties. This item is generally identified as "Bituminous material for mix" or "asphalt cement" and has a unit price per ton. Pay adjustments for asphalt properties are applied to this item.

The application of the specific pay adjustment factors to the contract unit price is an important element of the specification. A single deficiency is defined as a deficiency involving only one characteristic of a material within any one lot. When a single characteristic deficiency occurs, the pay factor is applied directly to the unit price of the affected item to determine an adjusted price.

The effects of multiplicative relationships of pay adjustment factors is approached in several different ways. A multiple deficiency is defined as deficiencies involving more than one characteristic of a material within a lot. The three different approaches currently used by the agencies which submitted specification information are the application of the lowest pay factor, application of the average of all

the pay factors, and application of the multiplied value of all pay factors. Examples of each of these are given by the following specification excerpts.

a) Lowest pay factor - Georgia Specification 400.06 A.

> "When two or more pay factors for a specific acceptance lot are less than 1.0, the adjusted payment will be determined by multiplying the contract unit price by the lowest pay factor."

b) Average of pay factors - Mississippi Specification 401.22 B

> "The final percentage for each lot, any of which characteristics for asphalt content, gradation, density, and stability are not within reasonably close conformity, shall be determined as in the following example.
>
> "Assume price adjustment for asphalt content is 90 percent, for the No. 200 sieve is 70 percent, for density is 100 percent and for stability is 100 percent.
>
> "Thus the final pay factor for that lot would be:
>
> $$\frac{90\% + 70\% + 100\% + 100\%}{4} = 90\%$$"

c) Product of all pay factors - Nebraska Specification Subsection 507.13.

> "...that lots of asphaltic concrete, accepted by the Engineer, shall be paid for at the contract unit price per ton for the item,..., mulitplied by product of the lot pay factors for asphalt content, retention on the applicable control sieves, and density of the compacted asphaltic concrete.
>
> "If the mean result of the lot acceptance tests for asphalt content, or for any of the control sieves or density, deviates from the target value or required minimum by more than the extreme value shown under 0.70 pay factor as specified herein, or if the product of the lot pay factors is less than 0.70, the Engineer may order the removal of any or all such material in the lot. The pay factor for any such material which is allowed to remain in place will be 0.40."

Compaction

Twenty-three state agencies submitted information on their use of

pay adjustment factors for noncompliance with compaction requirements. There is a wide disparity between the agencies with ten different approaches used for determination of the pay adjustment factor. In addition, the agencies using the same approach have widely varying values for the pay factor applied to a common level of compaction.

The ten approaches used are listed below. The number in brackets is the number of agencies using that approach. Details of the approach and specific pay factor values are given in Appendix C.

A) Percent of reduction in contract price computed by a formula based on statistics [3]

B) Pay factors for percent of target density [7]

C) Pay factors for percent of control strip density [4]

D) Pay factors for percent of voidless density [1]

E) Pay factors for daily mean air void content[1]

F) Pay factors based on deviation of air void content [1]

G) Price adjustment for percent of deficiency [1]

H) Pay factors based on a computed quality level [2]

I) Pay factors based on a computed quality index [1]

J) Pay factors for percent within limits [2]

There is little value in comparing the various approaches and their effects on the contract unit price unless actual data could be obtained on a common sample. This is beyond the scope of this writing. However, the tendency for widely divergent approaches to cause confusion and dissatisfaction among the contractors is of concern.

The use of pay adjustment factors determined by comparing the in-place density to the target or lab density appears to be the most com-

mon approach. The in-place density is typically determined with a nuclear gage and the target or lab density is determined for samples prepared by the Marshall Mixture or Hveem design procedures. The percent of target density achieved is then compared to predetermined values in the agency's specifications.

For most of the seven agencies, Table C-2 shows that achievement of at least 95 percent of target density qualifies for full payment for the material within that lot. The lower value in the tables specifies achievement of 91-92 percent of target density before the agencies seriously question achievement of reasonably close conformance. Values below this require the engineer to make further evaluations and give a decision on acceptance of that lot at a further reduced pay factor or total rejection. Most agencies also give the contractor an option of accepting the pay adjustment or removing and replacing the material at their own expense in an effort to achieve work which is in compliance.

The tabular values for the percent of target density are relatively uniform for most of the agencies using this approach. However, disparity is evident when evaluating the pay adjustment factors applied to each level of achievement. For example, the pay adjustment factor for achieving 93 percent of target density varies from 50 percent in one state to 96 percent in another state and at least two agencies may apply an even lower pay factor based on the decision of the engineer in charge.

Comparisons between agencies using one of the other approaches

is difficult since only one or two agencies reported use of each method. However, in the cases where several agencies use the same approach, the above mentioned disparity in pay adjustment factor values is also evident. A factor making analysis difficult in the approaches using statistical concepts is the possible variance in upper and lower tolerance limits. A pay adjustment schedule which appears to be more stringent may actually be more lenient if applied with a wider range of tolerances.

Asphalt Content

Information on pay adjustment factors for asphalt content was submitted by 25 agencies. This material characteristic also has a wide disparity of pay factors among the state agencies with eight different approaches being used. These are listed below with the details of each approach given in Appendix C.

A) Percent of reduction in contract price computed by a formula based on statistics [3]

B) Pay reduction for percent out of tolerance [3]

C) Pay factors for the average deviation from the job mix [13]

D) Pay factors for the percent within limits [2]

E) Pay reduction for the deviation of the sample average as percent [1]

F) Pay factors based on the deviation of the mean above or below the mix tolerances [1]

G) Price adjustment computed by a specified procedure based on percent of asphalt above or below the mix design tolerance [1]

H) Pay factors for the degree of nonconformance of the moving average [1]

Comparison of the various approaches with each other is difficult because most of them involve the application of specified tolerance levels, many of which were not submitted. In addition, data are not readily available on a common sample which could be analyzed using the individual approaches. However, similar to the compaction criteria, there is concern with the tendency for widely divergent approaches causing confusion and dissatisfaction among the contractors.

As noted above, 13 agencies use the same basic procedure. The pay adjustment factors as shown in Table C-13, are developed relative to the average deviation of the lot samples from the job mix criteria. The job mix is sometimes developed by the Contractor and submitted to the agency for approval. The target value established for asphalt content is then used for comparison with the actual asphalt content of the lot samples as determined by extraction methods.

The pay factors are applied to levels of the average deviation of the sample values to the job mix target value. Note that in all cases the pay adjustment is applied when the deviation is either above or below the job mix. There is a wide disparity in both the levels of deviation and related pay factors. For example, the average deviation may vary from 0.21 in one state to 0.55 in another state and qualify for full payment for that lot. On the other end of the spectrum, the maximum deviation where the agency considers total rejection varies from 0.27 to 1.10. The net result is that if a contractor provided the same material in terms of asphalt content in two different states, the material could be rejected in one state and accepted at full payment in the other.

The pay adjustment factors for the state of Illinois as shown in Table C-13, are of special interest. Based on the survey information, they are the only agency to offer a bonus for the achievement of quality work. Illinois provides a pay adjustment factor of 105 percent when the work is extremely uniform and has only minor deviations from the job mix target value.

Mix Gradation

Twenty-four agencies responded with detailed information on their pay adjustment factors for noncompliance with mix gradation requirements. The disparity in the pay factors is evident in the seven different approaches used. Details of these approaches as listed below are given in Appendix C.

A) Percent of reduction in contract price computed by a formula based on statistics [4]

B) Pay factors for deviation of the mean from the mix formula [14]

C) Pay reduction for percent within limits [1]

D) Pay reduction for deviation of the sample average as a percent of the mix tolerance [1]

E) Pay reduction for the percent out of tolerance [3]

F) Pay factors for the degree of noncomformance [1]

G) Pay adjustment computed by a detailed procedure in the specification [1]

The majority of the responding agencies use a common method for identifying pay adjustment factors. These 14 agencies base their pay factors on the deviation of the mean of the lot samples from the target values of the job mix formula for each sieve size evaluated. The job

mix formula is sometimes developed by the contractor and submitted to the agency for approval. The target value established for each sieve size is then used for comparison with the actual sample values.

The pay factors are applied to levels of the deviation as shown in Table C-19. Note that in all cases the deviation is applicable both above and below the mix formula target. This table also identifies the four sieve sizes (3/8, No. 4, No. 8 and No. 200) most commonly used in evaluating the characteristics of mix gradation. Several agencies include additional sieve sizes in their evaluations, but they were deleted from this summary for clarity.

The disparity in the pay adjustment factors between the various state agencies is evident in all four categories of sieve sizes. The No. 200 sieve appears to be the critical size with more constrictive tolerance levels applied. This is somewhat verified by several of the other approaches which apply a higher pay reduction to deviations on the No. 200 than on other sieve sizes. Therefore, the following discussion will be limited to the No. 200 sieve, realizing that the pay factors for the other sieve sizes follow a similar pattern. In cases where more than one sieve size proved deficient, the lowest pay factor is generally applied.

The allowable deviation of the mean of the lot size from the mix formula target value for which full payment will be made varies from 0.1 in one state up to 2.3 in another state. The higher values in the tables specify an allowable deviation of 1.35 to 5.4 before the respective agencies consider total rejection. Values greater than these require the engineer to make further evaluations and give a decision on acceptance of that lot at a greater reduced pay factor or total rejection.

For example, assume that the job mix target value is ten percent passing the No. 200 sieve. Further assume that a contractor produces a mix with eight percent passing the No. 200 sieve, a deviation of 2.0. This could result in pay adjustments, depending on the agency accepting the work varying from total rejection up to and including full pay for that lot of material.

Special attention should be given to the pay adjustment factors for the state of Illinois as shown in Table C-19. Again they appear to be the only state currently applying a bonus for the achievement of high quality work. Illinois provides a pay adjustment factor of 105 percent when the work is extremely uniform and has only minor deviations from the mix formula target value.

Thickness

Only three agencies provided schedules of pay adjustment factors for application to the thickness of the completed asphalt concrete pavement. As indicated in the earlier discussion on thickness in response to Question 3 of the questionnaire, almost half of the agencies do not accept a pavement thickness which is below the specification tolerances. Most of these agencies specify that an overlay is required to bring the thickness up to specification at the contractor's expense. Several agencies also have a form of pay adjustment for deviations above the specified thickness. For thicknesses which exceed that shown on the plans by more than one-half inch, an amount equal to the computed weight of that material in excess of the tolerance limit will be deducted from the weight determined from the weigh slips.

Of the three agencies which submitted information on pay adjustment factors each used a different approach. These approaches, as listed

below, are illustrated in Appendix C.

A) Pay factors for the percent of lot area outside acceptance limits

B) Pay factors based on a computed quality index

C) Pay factors for variance from the plan thickness

The effects of these three different approaches on a project can be easily evaluated by looking at an example. Assume a specified thickness of six inches is required and the lot samples provide thickness values as follows:

Sublot #1	Sublot #2	Sublot #3
5.50 inches	5.60 inches	6.10 inches
5.40	5.70	5.80
5.35	6.30	5.20
5.25	6.25	5.35
6.00	6.50	5.40

Using New Jersey's criteria:

$$QL = \frac{\text{Ave lot thickness - Thickness acceptance limit}}{\text{Average Range}}$$

where: Average Lot Thickness = average of all 15 samples from the three sublots.

= 5.71 inches

Thickness Acceptance Limit = 5.3 inches for a 6" total thickness based upon specification criteria.

Range Sublot #1 = 6.00 - 5.25 = 0.75

Range Sublot #2 = 6.50 - 5.60 = 0.90

Range Sublot #3 = 6.10 - 5.20 = 0.90

$$\text{Average Range} = \frac{0.75 + 0.90 + 0.90}{3} = 0.85$$

$$QL = \frac{5.71 - 5.30}{0.85} = 0.48 \longrightarrow \text{Pay Factor} = 100\% \text{(from Table C-24)}$$

Using Iowa's criteria:

$$QI = \frac{\text{Ave thickness - (Design thickness - 0.5)}}{\text{Max thickness - Minimum thickness}}$$

Average Thickness = average of 15 samples

= 5.71 inches

Maximum Thickness - Minimum Thickness = 6.50 - 5.20 = 1.30 inches

$$QI = \frac{5.71 - 5.50}{1.30} = 0.16 \longrightarrow \text{Pay Factor} = 85\% \text{ (from Table C-25)}$$

Using Illinois' criteria:

Variance = Design Thickness - Lot Average

Variance = 6.00 - 5.71 = 0.29 ⟶ Pay Factor = 90% (from Table C-26)

The results of this example show that even for a characteristic such as thickness, which can be related to pavement life through design equations, the pay factors are evaluated differently by the various agencies.

Smoothness

Six agencies provided information on pay adjustment factors for smoothness criterion. These agencies use four different approaches for identifying pay adjustment factors for various levels of product quality. The four approaches, as listed below, are presented in Appendix C.

A) Pay factors for the number of defects per lot [1]

B) Pay factors for percent of length exceeding tolerances [2]

C) Pay factors based on profile index [1]

D) Pay factors based on BPR Roughometer [2]

Due to the variety of measurement methods, it is impossible to compare the results these various systems would provide on a particular project. The questionnaire responses indicate that these approaches all attempt to base their pay adjustment factors on the increased maintenance requirements for pavements which are below specification.

Asphalt Properties

Information on pay adjustment factors for asphalt properties was provided by nine state agencies. The characteristics included in evaluation of the asphalt properties vary widely from state to state, but almost all agencies include a check of the viscosity. The tabular information presented in Appendix C for asphalt properties covers only portions of the viscosity tolerances and the associated pay adjustment factors. Other characteristics which are evaluated by some agencies include penetration range, percent residue, and flash point.

Three approaches are used by the nine agencies in identifying pay factors for various levels of material quality. These approaches are as follows:

A) Percent of reduction in contract price computed by a formula based on statistics [2]

B) Pay factors for levels of viscosity (140°F) [6]

C) Pay factors for percent deviation from the specification [1]

Comparisons between the three approaches for a specific situation is difficult. However, the disparity of the pay adjustment factors between states is clearly illustrated by evaluation of Table C-32, which provides information on pay factors for five agencies.

Using AC 20 as an example, all the agencies allow for full payment when the viscosity (140°F) is in the range of 1600-2400 poises. The disparity occurs in the pay adjustment factors for viscosity levels above or below the basic range. For instance, a viscosity of 1350 poises would have pay factors ranging from 75 percent to 100 percent depending on which agency was evaluating the asphalt cement.

CONCLUSIONS AND RECOMMENDATIONS

The pay factor questionnaire, prepared and distributed by the Oregon State Highway Division and Oregon State University, has proved to be an extremely useful tool in evaluating the current status of quality control procedures and the use of pay adjustment factors in the construction of asphalt concrete pavement projects. The 92 percent response rate by the state agencies is a key factor in the value of this report and is also an indication of the intense interest in this aspect of the construction process.

Conclusions

The data from the questionnaires were summarized and the analysis of the results for the 47 agencies which responded indicate that:

1) Almost all state agencies, 91 percent, will accept one or more properties in the construction and materials of asphalt concrete pavement that are outside specification tolerances.

2) The specific properties accepted outside of specification tolerances by a large majority of the agencies are compaction, asphalt content, asphalt properties, and mix gradation. The pavement thickness and smoothness are additional properties accepted outside of specification tolerances by approximately half of the agencies.

3) Most of the agencies which accept construction and materials outside of specification tolerances apply a pay adjustment in reducing the compensation to the contractor. It is important to note that the current philosophy is to penalize the contractor for properties which are below specification. A few agencies are considering the provision of a bonus for properties which are found to be above specification and

provide increased pavement serviceability or life. Illinois appears to be the only state agency which currently provides a bonus for high quality and uniform work.

4) The background relied on for establishing pay factors is predominately experience.

5) Only 26 percent of the agencies consider their pay factors to be proportional to reduced pavement serviceability. Other widely used rationale for pay factors are to discourage noncompliance by application of the penalty and to comply with recommendations of the FHWA.

6) Approximately one-half of the agencies consider the use of pay factor plans as effective in encouraging compliance with specifications. The remaining agencies either will not use specified pay factors or they don't believe the plans currently available are sufficient.

7) There is a wide disparity in the pay adjustment factors currently used by the different state agencies. There are several approaches used for determination of pay factors for each material property evaluated. In addition, agencies using the same approach have widely varying values for the pay factor applied to a common level of material quality.

Recommendations

The analysis of the questionnaire illustrates the controversial nature of the concepts of accepting noncompliance construction and materials and the application of pay adjustment factors. The following recommendations are made for the purpose of clarifying some of the critical issues and to develop a defendable rationale for these

concepts.

1) Continue research and testing on current paving projects to assess the effects of variations from specification limits of construction and material properties. The current joint project being conducted by the Oregon State Highway Division and Oregon State University is an example.

2) Use current research results and data available from past projects to identify the design characteristics or properties which are critical to pavement serviceability and life.

3) Develop a uniformly accepted, equitable pay adjustment format which is based on sound engineering principles that are defendable. The use of layered elastic analysis and appropriate failure criteria should be considered in preference to the current practice of using standard design procedures such as the AASHTO flexible pavement design method.

4) Evaluate the applicability of including bonus payments for construction or materials which are above specification tolerances and provide increased pavement serviceability or life.

REFERENCES

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2. "The AASHO Road Test: Report 5-Pavement Research", HRB Special Report 61E, 1962.
3. "Statistically Oriented End-Result Specifications", NCHRP Synthesis of Highway Practice; Transportation Research Board, 1976. 40 pp.
4. "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP-79, FHWA.

APPENDIX A

Copy of Questionnaire

OREGON STATE HIGHWAY DIVISION

Questionnaire On Pay Adjustment Factors

for

Asphalt Concrete Mixtures

NOVEMBER 1979

Agency_____ Reported by_____

Address_____ Title _____

Date Completed_____ Telephone No._____

Please answer the following questions with reference to your current methods for acceptance or rejection of asphalt concrete paving materials. Should there be additional information (in the form of research reports, internal memos, current standard procedures, proposed methods, etc.) which would supplement your answers to the questions, we would appreciate copies of these.

1. Do you accept asphalt concrete pavement construction and materials that do not satisfy specification requirements:

   Without payment adjustment?_____

   With payment adjustment?_____

2. What properties do you evaluate to establish the acceptability of an asphaltic concrete pavement? (Please include a copy of test procedure if not AASHTO.)

Property	Yes	No	Method of Test
Thickness	___	___	_____
Smoothness	___	___	_____
Compaction	___	___	_____
Asphalt Content	___	___	_____
Asphalt Properties	___	___	_____
Aggregate Quality	___	___	_____
Mix Moisture Content	___	___	_____
Mix Gradation	___	___	_____

3. What are your pay adjustment factors for each of the properties identified in No. 2 above? Please provide any available written procedures for the determination of payment.

Property	Range or Tolerance	Pay Adjustment
Thickness		
Smoothness		
Compaction		
Asphalt Content		
Asphalt Properties		
Aggregate Quality		
Mix Moisture Content		

3. (continued)

Property	Range or Tolerance	Pay Adjustment
Mix gradation		
1 inch	_____	_____
3/4 inch	_____	_____
_____	_____	_____
#4	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
200	_____	_____

4. How were your pay adjustment factors established?

____laboratory results ___field studies ___experience ___other

Please provide any available written procedures used to establish the pay factors.

5. Is your pay adjustment proportional to the value of reduced pavement serviceability resulting from specification noncompliance? ___yes ___no. If not, what is your rational for establishing pay adjustments? (Such as cost of production, cost of quality control, other.)

_____

_____

_____

6. Do you feel your pay adjustment factors are effective in encouraging compliance with specifications?

___yes ____no ____don't know

7. Please summarize your opinion regarding the need for pay adjustments or the success of your method for acceptance of paving materials.

_____

_____

Would you like to receive a summary of information from this survey?

____yes ___no.

Please return by January 1, 1980 to: James E. Wilson, Jr.
Assistant Engineer of Materials
Oregon State Highway Division
Salem, Oregon 97310

APPENDIX B

Tabular Presentation

of

Detailed Questionnaire Results

Table B-1. Summary of Questionnaire Data Regarding Properties Tested for Pavement Acceptance.

State	Properties Tested																				
	Thick.[A]			Smooth.[B]			Compt.[C]			Asphalt Cont.[D]			Asphalt Prop.[E]			Agg. Qual.[F]			Mix Mois. Cont.[G]			Mix Grad.[H]		
	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**
ALABAMA	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	-	4	Y	1	4
ALASKA	Y	2	5	Y	1	5	Y	1	1	Y	2	1	Y	2	5	Y	2	4	N	-	-	Y	2	1
ARIZONA	Y	1	4	Y	1	4	Y	1	4	Y	3	4	Y	2	2	Y	2	4	Y	1	4	Y	3	2
ARKANSAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CALIFORNIA	Y	2	4	Y	2	5	Y	2	5	Y	2	5	Y	2	5	Y	3	5	Y	2	5	Y	2	5
COLORADO	N	-	-	N	-	-	Y	1	1	Y	2	1	Y	2	1	Y	2	1	N	-	-	Y	4	1
CONNECTICUT	Y	2	1	-	-	-	Y	4	1	Y	1	1	Y	2	1	Y	2	4	-	-	-	Y	1	1
DELAWARE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FLORIDA	Y	1	1	Y	1	1	Y	1	1	Y	1	1	Y	2	1	N	-	-	N	-	-	N	-	-
GEORGIA	Y	1	4	Y	1	3	Y	2	4	Y	4	1	Y	2	4	Y	2	4	Y	2	5	Y	1	1

*Property Evaluated
Y) yes
N) no
-) no response

**Pay Adjustment Basis
1) statistical
2) guide in spec.
3) schedule-not in spec.
4) none
5) negotiated

A-Thickness Tests
1) cores
2) others

B-Smoothness Tests
1) straight edge
2) various roadmeters

C-Compaction Tests
1) nuclear gage
2) procedure spec.
3) cores
4) other AASHTO

D-Asphalt Content Tests
1) AASHTO T-164
2) modified-extraction
3) tank stickings
4) procedure spec.

E-Asphalt Properties Tests
1) quality assurance
2) AASHTO

F-Aggregate Quality Tests
1) approved source
2) AASHTO
3) modified AASHTO

G-Mix Moisture Content Tests
1) modified T-111
2) other modified AASHTO
3) standard moisture tests

H-Mix Gradation Tests
1) AASHTO T-164
2) modified AASHTO
3) other AASHTO
4) own tests

Table B-1 (continued)

State	Properties Tested																							
	Thick.[A]			Smooth.[B]			Compt.[C]			Asphalt Cont.[D]			Asphalt Prop.[E]			Agg. Qual.[F]			Mix Mois. Cont.[G]			Mix Grad.[H]		
	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**
HAWAII	Y	1	4	Y	1	4	Y	5	2	Y	4	4	Y	2	4	Y	2	4	Y	3	4	Y	3	4
IDAHO	Y	1	4	Y	1	4	Y	1	4	Y	3	4	Y	2	2	Y	2	4	Y	3	4	Y	2	4
ILLINOIS	Y	2	1	Y	1	3	Y	1	1	Y	1	3	Y	1	3	Y	1	3	-	-	-	Y	1	1
INDIANA	N	-	-	Y	1	1	Y	1	1	Y	1	1	Y	-	5	Y	2	5	Y	-	5	Y	3	1
IOWA	Y	1	1	N	-	-	Y	2	2	Y	3	2	Y	2	2	Y	2	4	N	-	-	Y	1	2
KANSAS	N	-	-	N	-	-	Y	-	4	N	-	-	Y	-	4	Y	-	4	Y	-	4	Y	-	4
KENTUCKY	Y	1	2	Y	1	4	Y	1	4	Y	1	1	Y	2	1	Y	3	3	N	-	-	Y	1	1
LOUISIANA	N	-	-	Y	1	2	Y	4	2	N	-	-	Y	2	2	N	-	-	N	-	-	Y	1	2
MAINE	Y	1	5	Y	1	5	Y	4	5	Y	1	5	Y	2	5	Y	1	5	Y	3	5	Y	4	5
MARYLAND	N	-	-	N	-	-	Y	-	4	Y	1	1	Y	-	4	Y	-	4	N	-	-	Y	-	4
MASSACHUSETTS	Y	2	4	N	-	-	Y	4	4	Y	1	4	Y	2	4	Y	2	4	Y	1	4	Y	3	4
MICHIGAN	Y	1	3	Y	2	3	Y	1	3	Y	1	2	Y	1	2	Y	1	2	N	-	-	Y	1	4
MINNESOTA	Y	1	2	Y	1	2	Y	4	2	Y	-	2	Y	2	2	Y	2	2	N	-	-	Y	3	2
MISSISSIPPI	N	-	-	Y	1	1	Y	3	1	Y	1	1	Y	2	1	N	-	-	N	-	-	Y	1	1
MISSOURI	Y	1	3	Y	1	3	Y	4	3	Y	4	3	Y	2	3	Y	2	3	Y	3	3	Y	4	3
MONTANA	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	2	2	Y	2	4	Y	3	4	Y	1	4
NEBRASKA	N	-	-	N	-	-	Y	2	2	Y	4	1	Y	1	2	N	-	-	N	-	-	Y	4	1
NEVADA	N	-	-	Y	1	4	N	2	-	Y	4	4	Y	2	2	Y	2	4	Y	2	4	Y	4	4
NEW HAMPSHIRE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEW JERSEY	Y	2	2	Y	1	2	Y	4	2	Y	4	2	Y	1	4	Y	1	4	N	-	-	Y	4	2

Table B-1. (continued)

State	Properties Tested																				
	Thick.[A]			Smooth.[B]			Compt.[C]			Asphalt Cont.[D]			Asphalt Prop.[E]			Agg. Qual.[F]			Mix Mois. Cont.[G]			Mix Grad.[H]		
	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**	Eval.*	Test	Pay Adj**
NEW MEXICO	Y	1	2	Y	1	4	Y	1	4	Y	1	1	Y	2	1	N	-	-	N	-	-	Y	1	1
NEW YORK	Y	1	2	Y	1	4	Y	3	2	Y	1	4	Y	2	2	Y	2	4	Y	3	4	Y	1	4
NORTH CAROLINA	N	-	-	N	-	-	Y	1	4	Y	1	4	Y	2	4	Y	2	4	N	-	-	Y	2	4
NORTH DAKOTA	Y	1	4	Y	-	4	Y	1	2	Y	1	1	Y	1	4	Y	1	4	Y	3	4	Y	1	1
OHIO	N	-	-	Y	-	4	N	-	-	Y	1	1	Y	2	4	Y	2	4	N	-	-	Y	3	1
OKLAHOMA	N	-	-	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	2	4	N	-	-	Y	3	4
OREGON	N	-	-	Y	1	-	Y	1	2	Y	2	2	Y	2	2	Y	2	3	Y	3	2	Y	4	2
PENNSYLVANIA	Y	2	1	Y	-	1	Y	3	1	Y	1	1	Y	1	1	Y	1	1	Y	3	1	Y	1	1
RHODE ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SOUTH CAROLINA	N	-	-	Y	2	4	N	-	-	Y	1	1	Y	2	4	Y	2	4	N	-	-	Y	3	1
SOUTH DAKOTA	N	-	-	Y	-	4	Y	1	3	Y	4	3	Y	2	3	Y	2	4	N	-	-	Y	3	3
TENNESSEE	Y	1	4	Y	1	4	Y	1	4	Y	1	4	Y	2	4	Y	2	4	N	-	-	Y	3	4
TEXAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UTAH	Y	1	1	Y	1	1	Y	1	1	Y	1	1	-	-	-	-	-	-	-	-	-	Y	1	1
VERMONT	N	-	-	Y	2	2	Y	1	2	N	-	-	N	-	-	N	-	-	N	-	-	N	-	-
VIRGINIA	Y	1	4	Y	1	4	Y	1	4	Y	1	2	Y	2	4	Y	2	4	Y	1	4	Y	3	2
WASHINGTON	Y	1	4	Y	2	1	Y	1	1	Y	1	4	Y	1	1	Y	2	1	Y	3	4	Y	3	1
WEST VIRGINIA	Y	1	4	Y	2	2	Y	1	1	Y	1	1	Y	2	4	Y	1	4	Y	1	4	Y	3	1
WISCONSIN	Y	2	4	Y	1	4	Y	1	2	Y	1	4	Y	1	2	Y	2	4	N	-	-	Y	1	5
WYOMING	Y	1	1	Y	1	4	Y	1	4	Y	1	4	Y	2	2	Y	1	4	Y	3	4	Y	1	2
WASHINGTON D.C.	Y	1	1	Y	2	2	Y	1	4	Y	1	4	Y	2	4	Y	2	4	N	-	-	Y	3	4

Table B-2. Summary of Questionnaire Data Regarding Pay Factor Use.

State	Acceptance of below spec. material*	Background for pay factors				Pay Adjustment** proportional to service	Other rationale†	Pay factors effective**	Comments
		Lab result	Field study	Experience	Other				
ALABAMA	A						NU		Success excellent without pay factors
ALASKA	C			X		Y		Y	Forces contractor to improve quality control, creates uniformity
ARIZONA	C			X		N	2	N	Current specification not satisfactory
ARKANSAS	-								
CALIFORNIA	C			X		N	1	N	Factors must be based on sound engineering approach
COLORADO	C		X	X		N	4	Y	Reasonable and workable
CONNECTICUT	C		X		X	Y		Y	Greater contractor awareness of quality control
DELAWARE	B								Pay factors not used
FLORIDA	C							Y	Pay factors reduce contract administration and litigation

*Acceptance Below Spec.
A) Not Accepted
B) Accept without Adjustment
C) Accept with Adjustment
D) Combination of B & C
-) No response

**Responses
Y) yes
N) no
DK) Don't know

†Other Rationale
1) Cost of Replacement
2) Discourage Noncompliance
3) Rationalize Seriousness of noncompliance
4) Recommendations of FHWA
5) Cost of Production
6) Cost of Quality Control
NU) Not Used

Table B-2 (continued)

State	Acceptance of below spec. material*	Background for pay factors				Pay Adjustment ** proportional to service	Other rationale +	Pay factors effective**	Comments
		Lab result	Field study	Experience	Other				
GEORGIA	C		X	X	X	N	2	Y	Results in smoother roads, consistent mix, less state personnel
HAWAII	D				X	N	NU	DK	Compaction cases negotiated - no pay adjustment on others
IDAHO	A						NU	N	Don't believe in pay adjustment - shut contractor down
ILLINOIS	C								No opinion expressed
INDIANA	C			X		Y		Y	Practical engineering judgement must be exercised
IOWA	C	X	X	X		Y		DK	Valuable means of accepting noncompliance work
KANSAS	D			X		N	NU	DK	End-result way to go, but contractors resist
KENTUCKY	C			X		N	4	Y	Use too new to evaluate effects
LOUISIANA	C			X		N	6	Y	Equitable, easy to enforce, reduced effort in monitoring
MAINE	C						NU		Negotiate-contractor would increase bids if used pay factors.
MARYLAND	D						NU		Use guide to Dist. engineer for asphalt content only.
MASSACHUSETTS	A						NU		Negotiate few cases of accepted noncompliance
MICHIGAN	C	X	X	X		N		Y	Not used currently-evaluating use with bonus and penalty

Table B-2 (continued)

State	Acceptance of below spec. material*	Background for pay factors				Pay Adjustment ** proportional to service	Other rationale†	Pay factors effective**	Comments
		Lab result	Field study	Experience	Other				
MINNESOTA	C	X	X	X		Y		Y	Helps cover future maintenance costs
MISSISSIPPI	C			X		N	1	Y	Impartial method of dealing with substandard work.
MISSOURI	D			X		Y		Y	Pay factors result in poor quality work-use in special situations.
MONTANA	A			X		N	2	N	Better to monitor & insure quality than accept inferior.
NEBRASKA	C				X	N	4	Y	Experience excellent compliance
NEVADA	D	X		X		N	1	Y	Good for asphaltic products, cumbersome for aggregate & mix
NEW HAMPSHIRE	-								
NEW JERSEY	C			X	X	Y		Y	Has forced industry to develop quality control
NEW MEXICO	C				X	Y		DK	Promote integrity of specifications
NEW YORK	C			X		Y		N	Field inspection and testing required for quality control
NORTH CAROLINA	B						NU		Plan to develop end-result specification
NORTH DAKOTA	C		X			Y		Y	Can't measure reduced serviceability-developing stricter tolerances
OHIO	C			X		N	2	Y	Contractor responsible for quality control very effective

Table B-2 (continued)

State	Acceptance of below spec. material*	Background for pay factors				Pay Adjustment ** proportional to service	Other rationale+	Pay factors effective**	Comments
		Lab result	Field study	Experience	Other				
OKLAHOMA	B						NU		
OREGON	D	X	X	X	X	N	1	N	Pay adjustment needs to be more stringent on work rejected
PENNSYLVANIA	D	X	X			N	3	Y	Forces contractor to upgrade quality control program
RHODE ISLAND	-								
SOUTH CAROLINA	C	X	X	X		N	3	Y	Producers tend to emphasize quality control
SOUTH DAKOTA	C			X		N	2	Y	Provides option of conditional acceptance
TENNESSEE	B						NU		Interested in end-result spec. - current method good results
TEXAS	-								
UTAH	C				X	N	4	N	Cheaper for contractor to adj. pay than to meet spec.
VERMONT	C				X	N	4	N	Not impressed with past efforts at quality control
VIRGINIA	C			X		N	2	Y	Encourages quality control at plants
WASHINGTON	C			X	X	N	3	DK	Means of accepting noncompliance when removal not justified
WEST VIRGINIA	D	X	X	X	X			Y	Used to resolve minor deviations-provides contractor incentive.
WISCONSIN	C			X		Y		Y	Administration problems

Table B-2 (continued)

State	Acceptance of below spec. material*	Background for pay factors				Pay Adjustment** proportional to service	Other rationale†	Pay factors effective**	Comments
		Lab result	Field study	Experience	Other				
WYOMING	D			X		Y		Y	Pay factors only on tests made after the fact
WASHINGTON D.C.	C			X		N	2	Y	Used only on smoothness

APPENDIX C

Current Pay Adjustment Factors of State Agencies

PAY ADJUSTMENT FACTORS FOR COMPACTION

A. Percent of reduction in contract price is computed by a formula based on statistics. In addition to compaction, this method will also be referred to for determining the pay reduction on asphalt content, asphalt properties, and mix gradation. The states of Alaska, Colorado, and Washington use this method for compaction criteria.

The formula, $P = (\overline{X}_n + aR - T_U) \times F$, will be used if a maximum limit only is specified or; when the average of the test values representing the lot is above the mid point of the specification band or above the job-mix formula value.

The formula, $P = (T_L + aR - \overline{X}_n) \times F$, will be used if a minimum limit only is specified or; when the average of test values representing the lot is below the mid point of the specification band or below the job-mix formula value.

Where:

P is the percent of reduction in contract price,

$\overline{X}_n$ average of lot test values, with "n" the number of values,

a variable to be used as "n" changes according to the following:

n = 1	a = 1.00
n = 2	a = .7
n = 3	a = .5
n = 4	a = .4
n = 5	a = .3

R difference between highest and lowest values in the group test results from the lot,

T_U is the upper or maximum tolerance limit permitted by the specifications,

T_L is the lower or minimum tolerance limit permitted by the specifications, and

F is the price reduction factor to be applied for each element as shown in Table C-1.

Table C-1: Price Reduction Factors for Various Asphalt Paving Characteristics.

Characteristic	Factor "F"
Compaction	7
1/2 inch sieve and larger	1
3/8 - #10	2
#16 - #100	3
No. 200 sieve	6
Asphalt content	25
Asphalt penetration	1
AR-4000W, viscosity, 140°F, poises	0.05
MC 70, viscosity, 140°F, centistokes	0.7
MC 800, viscosity, 140°F, centistokes	0.08
MC 3000, viscosity, 140°F, centistokes	0.02
Asphalt residue	3

In cases where one or more elements show a positive P value, such positive values will be added and the resulting sum will be used to determine whether the material is in reasonably close conformity. If the total P is less than 3, or a negative quantity, the material will be accepted as being in reasonably close conformity. If the total P value is between 3 and 25, the Engineer may require correction or he may accept the material at a reduced price. If the total P is greater than 25, the Engineer may: (1) require complete removal and replacement with specification material at no additional cost to the State; (2) require corrective action to bring the material into reasonably close conformity at no additional cost to the State; or (3) where the finished product is found to be reasonably acceptable for the intended purpose permit the Contractor to leave the material in place with an appropriate price adjustment which may range from no payment to that which would have occurred had an adjustment been made where P = 25.

B. Percent of pay is tabulated relative to the in-place density as a percent of the target density or lab density. The in-place density is typically measured by nuclear gage and the target or lab densities are typically determined by the Marshall method. The pay factors for states using this method are given in Table C-2.

C. Percent of pay is tabulated relative to the percent of control strip density achieved, with the control strip at a minimum of 94 percent of the calculated voidless mixture based on the apparent specific gravity of aggregates. The pay factors for state agencies using this method are given in Table C-3.

Table C-2: Compaction Pay Factors for Percent of Target Density.
Based on 5 Samples per lot

Connecticut**		Hawaii		Louisiana		Mississippi	
% Target	% Pay	% Target	% Pay	% Target	% Pay	% Target	% Pay
95-100	100	95-100	100	94-100	100	94.9-100	100
90-94.9	90	94-95	99	93-93.9	95	94.2-94.8	90
87-89.9	85	93-94	96	91-92.9	80	93.5-94.1	70
<87	70*	92-93	93	<91	50	92.8-93.4	50
		91-92	85			<92.8	0
		90-91	69				
		<90	10*				

North Dakota		South Dakota†		Utah	
% Target	% Pay	% Target	% Pay	% Target	% Pay
97-100	100	95-100	95-100	96-100	100
96-97	97	94	90-95	92-95.9	90
95-96	93	93	80-90	<92	50*
94-95	85	92	70-80		
<94	75*	<91	40*		

* Engineer makes decision on acceptance at reduced pay or total rejection.
** Proposed for implementation in specifications in 1981.
† Guidelines used by agency in negotiating.

Table C-3: Compaction Pay Factors for Percent of Control Strip Density.

Florida		Georgia	
% Control Strip	% Pay	% Control Strip	% Pay
98-100	100	97.5-100	100
97-98	95	97-97.4	97
96-97	90	96.5-96.9	95
<96	75*	95.5-96.4	90
		93.5-95.4	80
		91.5-93.4	70
		90-91.4	50*

Indiana		Vermont	
% Target	Pay Reduction	% Target	% Pay
98-100	0	98-100	100
96-97.9	0.5% each 0.1% below 98	<98	92*
95-95.9	10% plus 1% for each 0.1% below 96		
<95	50%*		

*Engineer makes decision on acceptance at reduced pay or total rejection.

D. Percent of pay is tabulated relative to the percent of voidless density. Determination of the bulk specific gravity for each specimen is made using a modified AASHTO T-166 method. Table C-4 gives the pay factors for Nebraska which uses this method.

E. Percent of pay is tabulated relative to the daily mean air void content in the samples as determined by the Rice method. This method is being used by New York as an experimental specification and the pay factors are given in Table C-5.

F. Percent of pay is tabulated relative to the deviation of a five sample average either above or below the specified limits for air voids. The pay factors shown in Table C-6 are those used by New Jersey.

G. Price adjustment per unit is tabulated for the percent of compaction deficiency from the specified compaction. The pay unit is ½ mile of single lane pavement per lift and the specified target density is determined from a control strip based on the relative maximum density. Table C-7 shows the price adjustments used by the State of Oregon.

H. Percent of pay is tabulated relative to a quality level (QL) which is computed by one of the two following formulas. The pay factors for the agencies using these formulas are presented in Table C-8. The lab density, the mean core density and mean relative density are all based on Marshall tests.

a) $$QL = \frac{\text{Mean Lot Density}}{\text{Control Strip Target Density}} \times \frac{\text{Control Strip Mean Core Density}}{0.95 \times \text{Maximum Lab Density}}$$

b) $QL = \text{Mean Relative Density} - (0.60 \times \text{Range})$

Table C-4: Compaction Pay Factors for Percent of Voidless Density.

Nebraska	
% Voidless Density	% Pay
90-100	100
89.5-89.9	95
89.0-89.4	70

Table C-5: Compaction Pay Factors for Daily Mean Aid Void Content.

New York	
% Mean Air Void	% Pay
7.0 or less	100
7.1-8.0	95
8.1-9.0	90
9.1-10.0	80
10.1-11.0	70
11.1-12.0	50
>12.0	Reject

Table C-6: Compaction Pay Factors Based on Deviation of Air Void Content.

New Jersey		
Deviation above max. air voids	Deviation below min. air voids	% Pay
0.1-1.0	-	95
1.1-2.0	0.1-0.5	90
>2.0	>0.5	80

Table C-7: Compaction Price Adjustment for Percent of Deficiency.

Oregon	
Percent of Deficiency	Price Adjustment Per Unit
0.5 or less	None
0.6 thru 1.0	$ 25.00
1.1 thru 2.0	50.00
2.1 thru 3.0	85.00
3.1 thru 4.0	135.00
4.1 thru 5.0	200.00
5.1 and more - Subject to correction, rejection or higher deduction as Engineer determines	

Table C-8: Compaction Pay Factors Based on Quality Level.

Illinois (a)		Minnesota (b)	
QL	% Pay	QL	% Pay
99-101	105	>95.5	100
98-98.9	100	94.5-95.4	95
97.7-97.9	97	93.5-94.4	90
97.4-97.6	95	92.5-93.4	80
96.8-97.3	90	91.5-92.4	60
96.3-96.7	80	<91.5	Reject
<96.3	50*		

*Engineer makes decision on acceptance at reduced pay or total rejection.

I. Percent of pay is tabulated for values of quality index (QI) determined by a formula which relates the lot densities to a specified density. The specified density is 94 percent of the lab density based on Marshall tests. Table C-9 shows the pay factors for this method as used by Iowa.

$$QI = \frac{\text{Average Density \% - Specified Density \%}}{\text{Highest Density \% - Lowest Density \%}}$$

J. Percent of pay is tabulated relative to the percent within limits (PWL) estimated by the range method. The method for computing the PWL is given by the following procedure including reference to Table C-11. Pay factors for the two agencies using this method are given in Table C-10.

Procedure of Computing PWL

a) Find R by subtracting the smallest value from the largest value in a group of measurements.

b) Find the Quality Index Q_U by subtracting the average ($\overline{X}$) of the measurements from the upper specification limit (u) and dividing the result by R.

$$Q_U = \frac{(U - \overline{X})}{R}$$

c) Find the Quality Index Q_L by subtracting the lower specification limit (L) from the average ($\overline{X}$) and dividing the result by R.

$$Q_L = \frac{(\overline{X} - L)}{R}$$

d) Estimate the percentage of material that will fall within the upper tolerance limit by entering Table C-11 with Q_U, using the column appropriate to the total number (n) of measurements.

e) Estimate the percentage of material that will fall within the lower tolerance (L) by entering Table C-11 with Q_L, using the column appropriate to the total number (n) of measurements.

Table C-9: Compaction Pay Factors Based on Quality Index.

Iowa	
QI	% Pay
0.35+	100
0.17-0.35	95
0.00-0.16	85
Negative	75*

*Engineer makes decision on acceptance at reduced pay or total rejection.

Table C-10: Compaction Pay Factors for Percent Within Limits.

Pennsylvania		West Virginia	
PWL	% Pay	PWL	% Pay
90-99	95	85-100	100
85-89	90	80-85	98
80-84	80	75-80	97
75-79	70	70-75	93
70-74	60	<70	*
65-69	50		
<65	Reject		

*Engineer makes decision on acceptance at reduced pay or total rejection.

Table C-11: Estimating Percent of Lot Within Tolerance (Range Method).

Percent Within Tolerance	Negative Values of Q_U or Q_L					Percent Within Tolerance	Positive Values of Q_U or Q_L				
	n=3	n=4	n=5	n=6	n=7		n=3	n=4	n=5	n=6	n=7
50	0.00	0.00	0.00	0.00	0.00	99	0.60	0.66	0.66	0.65	0.65
45	0.09	0.07	0.06	0.05	0.05	98	0.60	0.64	0.65	0.62	0.61
40	0.19	0.13	0.11	0.10	0.09	97	0.60	0.63	0.62	0.59	0.58
39	0.20	0.15	0.13	0.11	0.10	96	0.60	0.62	0.60	0.57	0.55
38	0.22	0.16	0.14	0.12	0.11	95	0.60	0.60	0.48	0.55	0.53
37	0.24	0.17	0.15	0.13	0.12	94	0.59	0.59	0.57	0.53	0.51
36	0.26	0.19	0.16	0.15	0.13	93	0.59	0.58	0.55	0.51	0.49
35	0.27	0.20	0.17	0.16	0.14	92	0.59	0.56	0.53	0.49	0.47
34	0.29	0.21	0.18	0.17	0.15	91	0.58	0.55	0.51	0.48	0.46
33	0.31	0.23	0.19	0.18	0.16	90	0.58	0.54	0.50	0.46	0.44
32	0.32	0.24	0.21	0.19	0.17	89	0.57	0.52	0.48	0.45	0.43
31	0.34	0.26	0.22	0.20	0.18	88	0.56	0.51	0.46	0.43	0.41
30	0.36	0.27	0.23	0.21	0.19	87	0.55	0.50	0.45	0.42	0.40
29	0.37	0.28	0.24	0.22	0.20	86	0.54	0.48	0.44	0.40	0.38
28	0.39	0.30	0.25	0.23	0.22	85	0.54	0.47	0.42	0.39	0.37
27	0.40	0.31	0.27	0.24	0.23	84	0.53	0.46	0.41	0.38	0.36
26	0.41	0.32	0.28	0.25	0.24	83	0.52	0.44	0.40	0.36	0.34
25	0.43	0.34	0.29	0.27	0.25	82	0.51	0.43	0.38	0.35	0.33
24	0.44	0.35	0.30	0.28	0.26	81	0.50	0.42	0.37	0.34	0.32
23	0.46	0.36	0.32	0.29	0.27	80	0.49	0.40	0.36	0.33	0.31
22	0.47	0.38	0.33	0.30	0.28	79	0.48	0.39	0.34	0.31	0.29
21	0.48	0.39	0.34	0.31	0.29	78	0.47	0.38	0.33	0.30	0.28
20	0.49	0.40	0.36	0.33	0.31	77	0.46	0.36	0.32	0.29	0.27
19	0.50	0.42	0.37	0.34	0.32	76	0.44	0.35	0.30	0.28	0.26
18	0.51	0.43	0.38	0.35	0.33	75	0.43	0.34	0.29	0.27	0.25
17	0.52	0.44	0.40	0.36	0.34	74	0.41	0.32	0.28	0.25	0.24
16	0.53	0.46	0.41	0.38	0.36	73	0.40	0.31	0.27	0.24	0.23
15	0.54	0.47	0.42	0.39	0.37	72	0.39	0.30	0.25	0.23	0.22
14	0.54	0.48	0.44	0.40	0.38	71	0.37	0.28	0.24	0.22	0.20
13	0.55	0.50	0.45	0.42	0.40	70	0.36	0.27	0.23	0.21	0.19
12	0.56	0.51	0.46	0.43	0.41	69	0.34	0.26	0.22	0.20	0.18
11	0.57	0.52	0.48	0.45	0.43	68	0.32	0.24	0.21	0.19	0.17
10	0.58	0.54	0.50	0.46	0.44	67	0.31	0.23	0.19	0.18	0.16
9	0.58	0.55	0.51	0.48	0.46	66	0.29	0.21	0.18	0.17	0.15
8	0.59	0.56	0.53	0.49	0.47	65	0.27	0.20	0.17	0.16	0.14
7	0.59	0.58	0.55	0.51	0.49	64	0.26	0.19	0.16	0.15	0.13
6	0.59	0.59	0.57	0.53	0.51	63	0.24	0.17	0.15	0.13	0.12
5	0.60	0.60	0.58	0.55	0.53	62	0.22	0.16	0.14	0.12	0.11
4	0.60	0.62	0.60	0.57	0.55	61	0.20	0.15	0.13	0.11	0.10
3	0.60	0.63	0.62	0.59	0.58	60	0.19	0.13	0.11	0.10	0.09
2	0.60	0.64	0.65	0.62	0.61	55	0.09	0.07	0.06	0.05	0.05
1	0.60	0.66	0.66	0.65	0.65	50	0.00	0.00	0.00	0.00	0.00

f) In cases where both upper (U) and lower (L) tolerance limits are concerned, find the percent of material that will fall within tolerances by adding the percent (P_U) within the upper (U) tolerance to the percent (P_L) within the lower (L) tolerance and subtract 100 from the sum.

$$\text{Total percent with limits} = (P_U + P_L) - 100$$

PAY ADJUSTMENT FACTORS FOR ASPHALT CONTENT

A. Percent of reduction in contract price is computed by a formula based on statistics. Refer to item A under Compaction on page 64 for details of the computation procedure. This method is specified by the states of Alaska, Colorado and New Mexico.

B. Pay reduction is based on the percent out of tolerance for the samples obtained. These factors are given in Table C-12 for the respective agencies.

C. Percent of pay is tabulated relative to the average deviation of the lot samples from the job mix. Asphalt content is typically measured by extraction methods. Table C-13 gives the pay factors for the agencies using this method. Note that the pay adjustment factors are applied when the deviation is either above or below the job mix target value.

D. Pay adjustment is tabulated relative to the percent within limits (PWL) estimated by the range method. Refer to item J under Compaction on page 75 for details of the computation procedure. Table C-14 gives the pay factors for the agencies using this approach.

E. Pay reduction is tabulated relative to the deviation of the sample average as a percent of the job mix tolerance. The pay reductions for this approach are shown in Table C-15.

F. Percent of pay is tabulated relative to the deviation of the mean below the job mix tolerance as shown in Tabel C-16 or is computed by a formula when the deviation of the mean is above the job

Table C-12: Asphalt Content Pay Reduction for Percent Out of Tolerance.

State	Pay Reduction
Indiana	3% for each 0.1% out of tolerance
Minnesota	2% for first 0.1% out of tolerance 5% for each 0.1% above 0.1%
Virginia	1% for each 0.1% out of tolerance

Table C-13: Asphalt Content Pay Factors for Average Deviation From Job Mix.
Based on 5 samples per lot**

Connecticut		Florida		Georgia		Illinois		Iowa		Kentucky		Maryland	
Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay
0.44-0.2(R)*	100	0.0-0.35	100	0-0.41	100	0.25-0.3(R)	105	0.0-0.4	100	0.0-0.26	100	0.0-0.38	100
0.42	97	0.36-0.40	95	0.42-0.46	95	0.30	100	0.41-0.50	98	0.27-0.29	98	0.39-0.43	95
0.49	95	0.41-0.45	90	0.47-0.51	90	0.34	95	0.51-0.60	95	0.30-0.32	95	0.44-0.47	90
		>0.45	80	0.52-0.56	80	0.38	90	0.61-0.70	90	0.33-0.40	90	0.48-0.52	80
				0.57-0.61	70	0.44	80	0.71-0.80	85	0.41-0.48	85	0.53-0.56	70
				0.62-0.64	50	0.50	50-70	0.81-0.90	78			0.57-0.60	60
								0.91-1.00	70			0.61-0.64	50
								1.01-1.10	60				

Mississippi		Nebraska		North Dakota		Ohio		South Carolina		Utah	
Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay	Ave. Dev.	% Pay
≤0.18	100	0.0-0.31	100	≤0.55	100	0.0-0.45	100	0.0-0.21	100	0.0-0.38	100
0.24	90	0.32-0.37	95	0.83	97	0.46-0.49	95	0.22-0.25	95	0.39-0.43	95
0.30	70	0.38-0.41	90	0.96	94	0.50-0.54	90	0.26-0.27	90	0.44-0.47	90
0.36	50	0.42-0.45	80	1.10	90	0.55-0.58	80	>0.27	Engr.†	0.48-0.52	80
0.42	0	0.46-0.49	70	>1.10	Engr.†	0.59-0.63	77			0.53-0.56	70

*R = Range of sample values within lot being evaluated.

†Engineer makes decision on acceptance at reduced pay or total rejection.

** A few agencies use 4 samples per lot.

Table C-14: Asphalt Content Pay Factors for Percent Within Limits

Arizona*		Pennsylvania	
PWL	Pay Reduction per Contract Unit Price	PWL	% Pay
80-100	0	90-100	100
70-79	$ 0.50	88-89	99
60-69	1.00	85-87	98
50-59	1.50	80-84	95
0-49	2.00 or reject	77-79	90
		74-76	85
		72-73	80
		70-71	75
		< 70	reject

* Proposed plan not in specification

Table C-15: Asphalt Content Pay Reduction for Deviation of Sample Average as Percent of Mix Tolerance

New Jersey	
% of Tolerance	Pay Reduction
1-50	2%
51-100	5%
> 100	10% or reject

mix tolerance. The formula uses an adjustment factor which is related to the deviation as shown in Table C-17. This method is used by South Dakota as a guideline in negotiations for acceptance of noncompliance material.

Pay Factor for Deviation above Mix Tolerance

$$P.F. = 100 - \left[\frac{D(A)}{M} + R\right]$$

where: D = Deviation

A = Unit Price Bid on Asphalt

M = Unit Price Bid on Mix

R = Adjustment Factor (Table C-17)

G. Price adjustment is computed by a specified procedure based on the percent of asphalt above or below the mix design tolerance. The following procedure is used by Oregon.

For each failing test the percentage of asphalt above or below the mix design tolerance is tabulated together with the quantity of mix represented by that test. These two values are then multiplied to determine the equivalent quantity for which no payment will be made. The summation of these quantities for all failing tests is then multiplied by the asphalt bid price to determine the price adjustment. (Note: The dollar amount for this price adjustment may be increased after a further study of the detrimental affect of high or low asphalt content.)

H. Percent of pay is tabulated relative to the degree of nonconformance based on the moving average of test samples using the following formulas. These pay factors are shown in Table C-18.

Table C-16: Asphalt Content Pay Factors for Deviation Below Mix Tolerances

South Dakota	
Deviation	% Pay
0.1	99.5
0.2	98.5
0.3	96.5
0.4	94.0
0.5	91.0
0.6	87.5
0.7	84.0
0.8	79.5
0.9	75.0
1.0	70.0

Table C-17: Asphalt Content Adjustment Factor for Deviation Above Mix Tolerances

South Dakota	
Deviation	R
0.1	0
0.2	0
0.3	0.75
0.4	1.5
0.5	2.5
0.6	4.0
0.7	5.5
0.8	7.5
0.9	8.75
1.0	10.75
1.1	12.5
1.2	15.0

Table C-18: Asphalt Content Pay Factors for Degree of Nonconformance of Moving Average

West Virginia	
Q_U or Q_L	% Pay
0	100
0.1	95
0.2	90
0.3	86
0.4	81
0.5	75

$$Q_U = \overline{X} - UL \qquad \text{or} \qquad Q_L = LL - \overline{X}$$

where: UL = Upper Limit

LL = Lower Limit

$\overline{X}$ = Moving Average of Four Tests

PAY ADJUSTMENT FACTORS FOR MIX GRADATION

A. Percent of reduction in contract price is computed by a formula based on statistics. Refer to item A under Compaction on page 64 for details of the computation procedure. This method is specified by the states of Alaska, Colorado, New Mexico, and Washington.

B. Percent of pay is tabulated relative to the deviation of the mean of the lot samples from the job mix formula. The pay factors are shown in Table C-19 for the agencies using this method. Note that this table identifies the four sieve sizes typically specified. Some states include additional sieve sizes in their evaluations. The values of deviation in all cases are applicable both above and below the mix formula target levels.

C. Pay reduction is tabulated relative to the percent within limits (PWL) estimated by the range method. Refer to item J under Compaction on page 75 for details of the computation procedure. Table C-20 gives the pay factors currently proposed by Arizona for future inclusion in their specifications.

D. Pay reduction is tabulated relative to the deviation of the sample average as a percent of the job mix tolerance. Table C-21 shows the pay reductions used in this method.

E. Pay reduction is based on the deviation of the sample means beyond the mix tolerance. These factors are given in Table C-22 for the respective agencies using this method.

F. Percent of pay is tabulated relative to the degree of nonconformance (DN) based on the moving average of the lot samples. Table C-23 shows the pay factors for the DN as calculated by the formula:

Table C-19: Mix Gradation Pay Factors for Deviation of the Mean from Mix Formula
Based on 5 samples per lot +

State	3/8	No. 4	No. 8 or No. 10	No. 200	% Pay
Connecticut	6.62-0.2(Range*)	6.23-0.2(Range)	5.83-0.2(Range)	2.31-0.2(Range)	100
	6.3	5.9	5.6	2.19	97
	7.3	6.9	6.4	2.54	95
Florida	0 -4.0		0 -3.25	0 -1.50	100
	4.01-4.50		3.26-3.75		98
	4.51-5.0		3.76-4.25	1.51-1.70	95
	5.1 -5.5		4.26-4.75	1.71-1.90	90
	> 5.5		> 4.75	> 1.90	80
Georgia	0 -5.0	0 -5.2	0 -4.3		100
	5.1 -5.6	5.3 -5.8	4.4 -4.8		98
	5.7 -6.3	5.9 -6.4	4.9 -5.3		95
	6.4 -6.9	6.5 -7.0	5.4 -5.8		90
	7.0 -7.6	7.1 -7.6	5.9 -6.4		85
	7.7 -8.0	7.7 -8.0	6.5 -6.8		80
Illinois	3.5 -0.3(Range)	3.0 -0.3(Range)	3.0 -0.3(Range)	1.0 -0.3(Range)	105
	5.0	3.0	3.0	1.5	100
	5.3	3.4	3.4	1.7	95
	5.7	3.8	3.8	1.9	90
	6.3	4.6	4.6	2.2	80
	7.0	5.5	5.5	2.5	50-70
Iowa	0	0	0	0	100
	0.1 -4.0	0.1 -4.0	0.1 -3.0	0.1 -0.5	98
	4.1 -7.0	4.1 -7.0	3.1 -5.0	0.6 -1.0	96
	> 7.0	> 7.0	5.1 -7.0	1.1 -2.0	94
			> 7.0	--	92
				2.1 -4.0	90
Kentucky	0 -3.0	0 -3.9	0 -3.8	0 -2.0	100
	3.1 -3.4	4.0 -4.4	3.9 -4.3	2.1 -2.2	98
	3.5 -3.8	4.5 -4.9	4.4 -4.8	2.3 -2.5	95
	3.9 -4.6	5.0 -5.9	4.9 -5.8	2.6 -3.0	90
	4.7 -5.5	6.0 -7.2	5.9 -7.0	3.1 -3.7	85
Louisiana		0 -1.0		0 -1.0**	100
		1.1 -4.0		1.1 -3.0	98
		> 4.0		> 3.0	95
Mississippi	3.0	3.0	1.8	0.9	100
	4.0	4.0	2.4	1.2	90
	5.0	5.0	3.0	1.5	70
	6.0	6.0	3.6	1.8	50
	7.0	7.0	4.2	2.1	0
Nebraska	0 -4.6	0 -4.0		0 -1.8	100
	4.7 -5.2	4.1 -4.5		1.9 -2.0	95
	5.3 -5.8	4.6 -4.9		2.1 -2.2	90
	5.9 -6.3	5.0 -5.4		2.3 -2.4	80
	6.4 -6.9	5.5 -5.8		2.5 -2.6	70
North Dakota	1.0	5.0		2.0	100
	1.5	7.5		3.0	97
	1.8	8.8		3.5	94
	2.0	10.0		4.0	90
	> 2.0	> 10.0		> 4.0	Engr.
Ohio		0 -4.5	0 -3.6	0 -1.8***	100
		4.6 -5.4	3.7 -4.5	1.9 -2.7	95
		5.5 -6.3	4.6 -5.4	2.8 -3.6	90
		6.4 -7.2	5.5 -6.3	3.7 -4.5	80
		7.3 -8.0	6.4 -7.2	4.6 -5.4	70
South Carolina	0 -3.1	0 -3.1	0 -3.1	0 -1.04	100
	3.2 -3.7	3.2 -3.7	3.2 -3.7	1.05-1.25	95
	3.8 -4.0	3.8 -4.0	3.8 -4.0	1.26-1.35	90
	> 4.0	> 4.0	> 4.0	> 1.35	Engr.
Utah	0 -4.9	0 -4.8	0 -4.0	0-1.7	100
	5.0 -5.5	4.9 -5.4	4.1 -4.5	1.8 -1.9	95
	5.6 -6.1	5.5 -5.9	4.6 -4.9	2.0 -2.1	90
	6.2 -6.6	6.0 -6.5	5.0 -5.4	2.2 -2.3	85
	6.7 -7.2	6.6 -7.0	5.5 -5.8	2.4 -2.5	70

* Range: The difference between the largest and smallest acceptance test result of that day.
** No. 80 sieve instead of No. 200.
*** No. 100 sieve instead of No. 200.
\+ A few agencies use 4 samples per lot.

Table C-20: Mix Gradation Pay Reduction for Percent Within Limits

Arizona	
PWL	Pay Reduction per Contract Unit Price
80-100	0
70-79	$ 0.50
60-69	1.00
50-59	1.50
0-49	2.00 or reject

Table C-21: Mix Gradation Pay Reduction for Deviation of Sample Average as Percent of Mix Tolerance

New Jersey	
% of Tolerance	% Pay
1-50	2%
51-100	5%
> 100	10% or reject

Table C-22: Mix Gradation Pay Reduction for Percent Out of Tolerance

State	Pay Reduction
Indiana	3/8 - 1% for each 1% beyond tolerance No. 4 - 1% for each 1% beyond tolerance No. 8 - 1% for each 1% beyond tolerance No. 200 - 3% for each 1% beyond tolerance
South Dakota	3/8 - 1% for each 1% beyond tolerance No. 4 - 1% for each 1% beyond tolerance No. 8 - 1% for each 1% beyond tolerance No. 200 - 2% for each 1% beyond tolerance
Virginia	3/8 - 1% for each 1% beyond tolerance No. 4 - 1% for each 1% beyond tolerance No. 8 - 1% for each 1% beyond tolerance No. 200 - 3% for each 1% beyond tolerance

$$DN = \Sigma M(L - \overline{X}) + \Sigma M(\overline{X} - U)$$

where: M = 1 for 3/8, No. 4, and No. 8 sieves

M = 2.5 for No. 200 sieve

$\overline{X}$ = Average Samples

L = Lower Limit

U = Upper Limit

G. Pay adjustment is computed by a detailed procedure for a mix that does not meet substantial compliance. This procedure, used by Oregon, is given below.

a) List the percent outside specifications for each sieve size.

b) Sum the percent passing the #10 and passing the #40 sieve (from step a) and multiply by 1.5.

c) Multiply the percent passing the #200 sieve (from step a) by 2.0.

d) Add the results of steps b) and c) to the percent of all larger sieve sizes listed in step a).

e) Determine the aggregate weight (in tons) of the material represented by the test.

f) Multiply the results of step d) by the results of step e) to determine the equivalent quantity for which no payment will be made.

g) Sum the results of step f) for all failing tests.

h) The results obtained in step g) is multiplied by the bid price to determine the gradation portion of the price adjustment for mixtures that are not in substantial compliance.

Table C-23: Mix Gradation Pay Factors for Degree of Nonconformance

West Virginia	
DN	% Pay
0- 2.0	100
2.1- 4.0	98
4.1- 6.0	97
6.1- 8.0	93
8.1-10.1	85
> 10.1	Engr.

PAY ADJUSTMENT FACTORS FOR THICKNESS

A. Percent of pay is tabulated relative to the percent of the lot area which is outside the thickness acceptance limit as determined by a computed quality level (QL). These pay factors are shown in Table C-24.

$$QL = \frac{\text{Average Lot Thickness - Thickness Acceptance Limit}}{\text{Average Range}}$$

where:

Average Lot Thickness = Average of total thickness measurements from 15 cores

Average Range = Average of three R values if R is the range in total thickness in each group of five consecutive cores.

B. Percent of pay is tabulated relative to the quality index (QI) which is computed according to the following formula. The pay factors listed in Table C-25 are those used by Iowa.

$$QI = \frac{\text{Average Thickness - (Designated Thickness - 0.5)}}{\text{Maximum Thickness - Minimum Thickness}}$$

C. Percent of contract price is tabulated for the variance of the lot average either above or below the specification thickness. The pay factors used by Illinois for this method are given in Table C-26.

Table C-24: Thickess Pay Factors for Percent Lot Area Outside Acceptance Limits

New Jersey			
QL		% Lot Area Outside Limit	% Pay
Equal to or Greater Than	Less Than		
0.36	--	0-20	100
0.29	0.36	21-25	95
0.23	0.29	26-30	90
0.17	0.23	31-35	80
0.11	0.17	36-40	50
--	0.11	> 40	Remove or Overlay

Table C-25: Thickness Pay Factors Based on Quality Index

Iowa	
QI	% Pay
0.40+	100
0.17-0.40	95
0.00-0.16	85
negative	75*

* Engineer makes decision on acceptance at reduced pay or total rejection.

Table C-26: Thickness Pay Factors for Variance from Plan Thickness

Illinois		
Variance Inches	% Pay	
	Over Plan Thickness	Under Plan Thickness
0-0.15	110	110
0.16-0.25	100	100
0.26-0.35	90	90
0.36-0.45	70	70
0.46-0.55	40	Overlay
> 0.56	40	Overlay

PAY ADJUSTMENT FACTORS FOR SMOOTHNESS

A. Percent of pay is tabulated relative to the number of defects per lot (1/4 inch to 3/8 inch). The test is made with a rolling ten foot straightedge operated parallel to the centerline in each wheelpath of each lane. The pay factors as listed by Florida are shown in Table C-27.

B. Percent of pay is tabulated with respect to the percent of roadway length parallel to the centerline which is exceeding the surface tolerance. The test is made with a ten foot rolling straightedge. Table C-28 shows the pay factors for the agencies using this approach.

C. Percent of pay is tabulated relative to the profile index in inches per 0.1 mile. These measurements are made with a California Type Profilograph. Indiana uses the pay factors shown in Table C-29.

D. Percent of pay is tabulated relative to the values for roughness obtained by measurements with a BPR Roughometer. These measurements in inches per mile are identified with their respective pay factor in Table C-30.

Table C-27: Smoothness Pay Factors for Number of Defects per Lot

Florida	
Number Defects Per Lot	% Pay
1	100
2-3	95
4-5	90
6-7	85
> 7	75

Table C-28: Smoothness Pay Factors for Percent of Length Exceeding Tolerances

Louisiana			New Jersey	
1/8"	3/16"	% Pay	1/8"	% Pay
0-0.1	0-0.5	100	0-1.3	100
1.1-1.5	0.51-0.75	95	1.4-2.3	98
1.6-2.5	0.76-1.50	80	2.4-3.4	95
> 2.5	> 1.5	50*		

* Engineer makes decision on acceptance at reduced pay or total rejection requiring an overlay.

Table C-29: Smoothness Pay Factors Based on Profile Index

Indiana	
Profile Index Inches/0.1 Mile	% Pay
0-1.2	100
1.21-1.3	98
1.31-1.4	96
1.41-1.5	92

Table C-30: Smoothness Pay Factors Based on FHWA Roughmeter

Vermont		West Virginia	
Roughometer Inches/Mile	% Pay	Roughometer Inches/Mile	% Pay
0-100	100	0-81	100
101-110	98	82-95	90
> 110	95	> 95	Engr.

PAY ADJUSTMENT FACTORS FOR ASPHALT PROPERTIES

A. Percent of reduction in contract price is computed by a formula based on statistics. Refer to item A under Compaction on page 64 for details of the computation procedure. This method is specified by the states of New Mexico and Washington.

B. Percent of pay is tabulated with respect to the deviation from specification tolerances of various asphalt properties. While several agencies have pay factors for a variety of properties, viscosity is typically specified as shown in Tables C-31 and and C-32.

C. Percent of pay is tabulated for the percent deviation from specification limits for each characteristic of the asphalt evaluated. The pay factors for this method are given in Table C-33.

Table C-31: Asphalt Property Pay Factors for Viscosity (140°F) of Cut-Back Asphalts

Connecticut			Iowa		
MC 70	MC 800	% Pay	MC 70	MC 800	% Pay
30-44.9	500-599.9	75	58.2-64	668-733	80
45-59.9	600-699.9	90	64.1-69.9	734-799	90
60-69.9	700-799.9	95	70-140	800-1600	100
70-140	800-1600	100	141-164	1601-1740	90
140.1-155	1600.1-1750	95	165-188	1750-1880	80
155.1-170	1750.1-1900	90	189-212	1890-1960	70
170.1-240	1900.1-2200	75			

Table C-32: Asphalt Property Pay Factors for Viscosity (140°F) of Asphalt Cement.

Florida			Iowa		
AC 5	AC 20	% Pay	AC 10	AC 20	% Pay
340-374	1375-1499	80	595- 678	1160-1330	60
375-399	1500-1599	90	679- 746	1340-1470	80
400-600	1600-2400	100	747- 781	1480-1550	95
601-625	2401-2500	90	782- 799	1560-1590	98
626-660	2501-2625	80	800-1200	1600-2400	100
			1210-1240	2410-2480	98
			1250-1350	2490-2690	95

Kentucky			Louisiana	
AC 10	AC 20	% Pay	AC 30	% Pay
450- 559	900-1049	40	< 2399	95
560- 659	1050-1199	70	2400-3600	100
660- 759	1200-1349	85	> 3600	95
760-1349	1350-2520	100		
1350-1500	2521-2670	85		
1501-1650	2671-2820	70		
1651-1800	2821-2970	40		

Wyoming		
AC 10	AC 20	% Pay
< 720	< 1440	75
720- 739	1440-1479	85
740-759	1480-1519	90
760-779	1520-1559	95
780-1220	1560-2440	100
1221-1240	2441-2480	95
1241-1260	2481-2520	90
1261-1280	2521-2560	85
> 1280	> 2560	75

Table C-33: Asphalt Property Pay Factors for Percent Deviation from Specification.

Arizona	
% Dev.	% Pay
0-10	90
10-25	75
> 25	40 or reject