

METHODS  
OF  
SAMPLING, TESTING & PAYMENT  
OF  
ASPHALT CONCRETE

OUTLINE OF TALK  
FOR  
TWELFTH NEW JERSEY  
ASPHALT PAVING CONFERENCE

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Outline of Talk  
For  
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Asphalt Paving Conference

Intent: The intent of this presentation will be to describe the New Jersey Department of Transportation's statistically based methods of sampling, of distinguishing between acceptable and unacceptable material, and of payment for asphalt concrete. The talk will be essentially concerned with those methods that appear in the present Addenda-A of our 1961 Standard Specifications.

Introduction: In cooperation with the Bureau of Public Roads, about four years ago the Department of Transportation initiated a program directed toward the eventual adoption of statistically based control and acceptance procedures for highway construction. The use of statistical principles as an aid in the control of product quality has had long and successful application in many manufacturing industries. It was the firm belief of the Department that statistical methodology could also find practical application in the construction and materials aspects of its work.

That phase of the Department's program which dealt with asphalt concrete was completed last year. Since that time, numerous statistically based procedures and techniques have been incorporated into much of the

Departments work in the asphalt area. The recent revisions made in our Addenda-A specifications are the major consequence of the new approach. I am sure that many of you have seen the latest version of Addenda-A and are aware of the various changes.

In the revised Addenda specifications, it is now required that random sampling procedures be used in obtaining all samples for acceptance testing. This requirement brings into play the mathematical laws of randomization to insure that all samples will be truly unbiased representatives of the material from which they are taken. An additional change in Addenda-A has resulted in the establishing of many new specification limits and tolerances for use in judging a materials acceptability. These new tolerances and milits have been sized by using the principles of statistics so as to sufficiently allow for the normal variation that occurs in a good asphaltic concrete.

A new method of payment is also included in the revised version of Addenda-A specifications. By this method reduced payment is made to the contractor when material fails to conform to the specification limits. Exactly what constitutes a non-conforming or unacceptable material and the amount of the reduced payment are now completely spelled out in Addenda-A.

The remainder of this presentation will be concerned with a discussion of the historical background and the reasons for these changes in the Addenda-A specifications. To fully understand the discussion, one will need to be aware of some of the fundamentals of statistics. Since a number of you, I am sure, have little or no knowledge of Statistics, I will precede my discussion of the Addenda-A changes with a short

explanation of several of the basics of statistics and why they are applicable to asphalt concrete.

As far as the engineer or technician in highways is concerned, Statistics may be thought of as a branch of mathematics that is made up of methods and techniques for dealing with measurements and, particularly, the variation that occurs in measurements. In the area of asphalt construction, many different kinds of measurements are made to determine the quality of the various materials used. In this regard, a great deal of research has gone into the studying of patterns of variation of the different quality measurements or quality characteristics used for asphalt concrete. What has been found is that these quality measurements (Ex. asphalt content, stability, air voids, etc.) vary in a uniquely similar fashion. More important, it has been found that the degree and nature of these variations are mathematically describable by the techniques of Statistics.

1. To illustrate pattern of variation found

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2. When measurements increase frequency distribution approx. normal curve.

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3. Look at properties of normal curve

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- a. symmetrical
- b.  $\mu$
- c.  $\sigma$
- d. areas under curve related to  $\mu$  &  $\sigma$ .

4. Summary of Fundamentals - state enables us to describe material we are dealing with; need only to know  $\sigma$  and  $\mu$ .
5. Department decided to use knowledge to establish specification limits and tolerances that adequately allowed for variation.

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a. Problem of how wide to set tolerances - too wide allows for acceptance of bad product.

b. Problem of what is magnitude of  $\sigma$  in good material.

6. Most of past four years spent gathering  $\sigma$ 's - experiments, analysis of historical data,  $\sigma$  banks of BPR's and Materials Research Development Company, NCHRP Report <sup>34</sup> (#50 sieve).

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$\sigma$ 's for most often used mixes - 1,2,5

7. With  $\sigma$  known and  $\pm 2\sigma$  tolerance approach as a guide. Department then set out to revise existing specification tolerances on individual test results. Started with Job Mix tolerances on composition.

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- a. All tolerances  $\pm 2\sigma$  off job mix design
- b. Mix 1 + 5 example

8. In conjunction with setting job mix tolerances Addenda A was revised to insure that a mix would not be designed which could produce inadequate material.

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9. As a further requirement in the area of composition the Department decided to average several consecutive test results and place specification limits on this average. To understand the reasoning behind this action it is necessary to be aware of a relationship that exists between sample averages and the quantity or lot of material from which the samples come.

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10. To make use of property of sample averages it was necessary to first establish a lot size and the number of samples to averaged.

- a. Guidance from other states South Carolina, Louisiana, Virginia - 1500 tons
- b. Our testing capacities in Trenton indicated we could test 5 samples per lot
- c. Random sampling procedure added

11. With the ground work established it was then possible to set forth job mix tolerances on the five sample averages for a lot. Since the use of sample averages better enables a differentiation between good and bad material, wider tolerances and smaller produce risks could be permitted - width  $\pm 2.22 \frac{\sigma}{\sqrt{n}}$  and about 2-1/2% risk.

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12. With the tolerances for composition taken care of the other areas of Addenda-A - stability and air voids were turned to.

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13. Random sampling procedures established.

14. With the problems of properly sizing tolerances and setting adequate sampling procedures taken care of, the Department's next area of concern was that of "out of specification" or non-conforming material. It was the Department's belief that this situation could best be handled by establishing a "reduced payment schedule." By such a schedule reduced payments would be made for non-conforming material and the amount of reduction would vary depending on the degree of non-conformance. The basic idea here is that an out-of-spec. material will not give the serviceability of the specified material and therefore full-payment should not be made. However, the material may provide some serviceability and thus if left in the road some portion of the contract price should be paid.

To establish an equitable payment schedule three questions had to be answered:

1. What is to be considered non-conforming material?
2. At what level of non-conformance should the material be considered completely inadequate in the particular characteristic of concern?
3. What is to be the maximum payment reduction to be applied to a non-conforming material?

The answer to the first question was, in the Department's opinion, quite clear. Since specification limits had been altered to allow for normal variation, a lot of material having test results outside the governing limits should be considered non-conforming material.

The level of non-conformance at which a material should be considered completely inadequate was not as straightforward.

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1. Allowed and considered insignificant 2.5% to 5.0% outside specs.
  2. Judged that 15% to 20% would be point at which material should be judged inadequate.
14. Maximum payment reduction up in the air.
- a. B.P.R., other states used as guide.
  - b. Decided on: 15% for mixture characteristic  
20% for stability  
20% for air voids
  - c. A three level graduated payment schedule prepared for each quality characteristic with preceding figures as maximum penalty.
15. Example of Penalty Schedule for Stability.

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#### Summary

To summarize this large mass of information that I have thrown at you, the Department of Transportation has adopted statistically based methods for sampling, sizing specification tolerances, and payment for asphalt concrete. These methods are believed to be the best way to date of coping with the problem of evaluating asphalt concretes quality and providing payment consistent with that quality.