

Construction Practices

Clarence E. DeYoung, Iowa State Highway Commission

The first application of statistical quality control in American industry was made by Dr. Walter Shewhart of the Bell Telephone Laboratories during the 1920's. The development of this new methodology and its acceptance by other industries in the United States was very slow until the event of World War II.

About this time a new concept, statistical decision, was introduced. The Department of Defense, which was faced with a massive procurement program, recognized the utility of this technology and pioneered the general development and application of statistical-based process control and acceptance concepts to industrial products. This effort stimulated its application to a great variety of industrial products.

The rather startling experiences with construction control at the AASHO Road Test and the institution by the Bureau of Public Roads and state highway departments of a "record sampling program" are considered to have generated the first real active effort by highway engineers to explore the use of statistical concepts as a tool for the solutions of many quality assurance problems. Dr. Robert F. Baker, former Director of the Office of Research and Development of the Bureau of Public Roads, is cited as one of those who recognized its power and aggressively promoted its use. He believed this development should contribute as much to our ability as engineers as did the advancement of the elastic theory in the 19th century and the use of computers and new construction equipment of the 20th century.

The creeping pace for adoption of statistical concepts in the control and acceptance of highway construction can be compared to the evolution of the computer. During the past 6 years engineers have become knowledgeable on the subject and, with this, resistance on the grounds of practicality is diminishing and realistic progress has started.

Some of the first applications of these concepts were made on the Garden State Parkway in New Jersey and on the Illinois Toll Road. The first state to start using probabilities in the acceptance of construction was Mississippi, where a combination control chart-acceptance plan with variable sample size was developed and included in the 1967 Standard Specifications for the acceptance of soil-cement base and bituminous hot-mix construction. Now at least 10 other states and the Bureau of Public Roads, in their direct construction operations in Regions 8 and 9, are accepting construction or portions of the construction process with specifications based on statistical concepts. States included are California, Louisiana, West Virginia, North Dakota, South Carolina, Virginia, Illinois, New Jersey, Utah, and New York. Of this group, New York and California are accepting the process, while the remainder are accepting on a lot-to-lot basis.

Four states and the Bureau of Public Roads Region 15 have conducted recent simulation studies. In these cases, construction was accepted by the usual methods, and separate crews performed parallel sampling and testing to test the criteria for and requirements of various statistical plans. Those involved in this category include Ohio, Nebraska, Michigan, Indiana, and the Bureau of Public Roads. In addition, New York has completed a prototype model for computer simulation on an asphalt plant's production. New York's approach allows a wide latitude for experimenting with various control and acceptance schemes with minimum sampling.

Many states either in cooperation with the Bureau of Public Roads or by themselves have measured the variability of many facets of construction and are continuing to do so. Active studies using HPR cooperative funds are under way in Minnesota, Georgia, Connecticut, Pennsylvania, and Maine. Of course, many other states are exploring various concepts in the informal way. Iowa has used a variables plan based on unknown standard deviations and averages to determine what variations should be considered normal for present acceptable construction and to provide for automatic identification of construction where establishment of reasonable compliance with the specification may require some administrative action (1).

In summary, a total of 36 states have actively been engaged in some form of study or application of statistically oriented specifications for a control and acceptance of construction. More than one-third of these states now are using a statistically designed specification as a standard specification or as a special provision. Application of these concepts is developing at about the same rate in the United Kingdom and the Canadian Provinces.

This is a significant accomplishment considering that the words standard deviation and mean were words foreign to almost all of us just a few years ago.

The general consensus seems to be that more inventiveness is needed in applying statistical concepts to highway quality assurance and acceptance procedures and that adoption of a "standard" plan or plans is not feasible at this time. However, a number of acceptance applications have proved to be sound and are in general use at this time. Many of them are based on the work of G. J. Lieberman and G. J. Resnikoff performed under the sponsorship of the Office of Naval Research (2, 3). "Sampling Plans for Inspection by Variables" by Lieberman and Resnikoff are suitable for highway applications and were used on the AASHO Road Test (4, 5). The statistical applications embodied in the futurized version of federal project specification, FP-61 (6) are the basis of many specifications being written.

The pamphlet on "Quality Assurance Through Process Control and Acceptance Sampling" issued by the Bureau of Public Roads (7) and NCHRP Report 17 (8) are useful references on the principles of statistical quality assurance and acceptance in highway construction for those who are not versed in mathematical statistics.

REFERENCES

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