THE USE OF THE FIELD COHESION TESTER

Towards SPC/TQC in the
Micro-Slurry Surfacing Industry

by

R. BRUCE BENEDICT
VICE PRESIDENT

C/O BENEDICT SLURRY SEAL, INC.
P.O. BOX 127; ALPHA, OHIO 45301
PHONE: 513-298-6647
FAX: 513-426-3368

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Contributions by:

Daniel L. Jenkins, Lab Technician/QC
Alpha Laboratories

Mark Ishee, Field Manager
Ergon Technical Development

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A change is taking place in an increasing number of organizations in the USA and Europe. Heavy competition for a reduced market share, coupled with more critical demands from the user agency, have resulted in a need to improve efficiency if the organization is to survive. This change is manifesting itself in various ways. On a technical level, it means that cost is no longer the dominant factor in making purchasing decisions; neither is productivity any longer a guarantee of remaining in business. At the company level, it means the breaking down of barriers between management and operational staff, and between and within departments. The major element in the survival programs for these organizations is now quality - quality of product, service and working lives. It is evident that organizations must change in order to remain in business, and that those who do not do so will face sooner, rather than later, the harsh realities of redundancies and closures.

Various techniques, management strategies, company policies and government campaigns are involved in this program of change. Increased employee involvement, improved management, automated and continuous machines, just-in-time inventories and quality circles are all playing their part in the transformation. However, of all the programs relating to quality improvement, those which are company-wide are having the biggest impact, and statistical process control (SPC) is amongst the front runners in this respect. But more than anything else, it is providing everyone in the organization with a common means of communication and a focus for improvement: the control chart.

So what is SPC, and what makes it different from anything else? The title suggests the use of statistics, but it would be a mistake to assume that SPC is simply statistical analysis; it is much more than that.

Statistical. The word 'statistical' implies the collection, representation and interpretation of data. Statistical methods provide a means of assessing risks and predicting results. The word 'statistics' usually conjures up an image of a fearsome topic which can only be studied by those with advanced analytical skills. This misapprehension is due primarily to the effect of our Western educational system, which has overemphasized the need for academic excellence at the expense of professional capability.

The statistical element of SPC involves the simple handling of data and the understanding of a basic chart. The technique is capable of being understood by anyone, but involves training to various levels of competence so that the techniques are fully appreciated.

'Statistical' implies patterns of results, and the interpretation of such patterns, especially by operators, is a key feature of any SPC program.

Process. Any activity is a process. In the field, it is the combination of methods, people, materials, environment and equipment in the production of a component, or surfacing a street or filling a rut. However, there are also other processes, perhaps not recognizable as such at first. For example, the recruitment of new personnel, the preparation of the CDL, drug testing and the analysis of accident records are all processes, and they can be measured. The appropriate measure may not be as easily determined but nevertheless, such measures (called process performance measures, performance indicators or metrics) can be obtained.

Understandably, SPC tends to be associated with a chart on a machine; however, it must be seen in a wider context as being relevant to any department or any section of an organization, whether it be manufacturing, service, education or any other.

Control. SPC involves control followed by improvement. Processes are initially brought under control and then improved by reducing the variability about the nominal or, if appropriate, reducing the level of rejects to zero. A controlled situation avoids fire-fighting; the instantaneous reaction to problems as and when they occur. Control means that planning, prediction and improvement can follow.

Control by itself is not enough. Improvement is required; improvement to new levels of performance which leads to opportunities for further improvement, creating a cycle of continuous improvement. In practice there are practical and financial limitations to the extent of the improvements but the aim is perfection.

SPC itself is new, but the message it carries is not. The techniques of SPC date back to the 1920s and were first developed as part of statistical quality control (SQC). The switch from SQC to SPC is recent, and the change of name has had a profound bearing on the sudden resurgence of interest in the statistical aspects.

Four main factors influence an organization in its decision to implement SPC. These are listed in the slide.

External Pressure

For a number of companies, there is little choice; they are being told by their customers to implement SPC programs if they wish to retain their contracts with user agencies.

There is no doubt that other industries and government agencies have adopted this approach. One of the Malcolm Baldridge award winners for small businesses this year is Granite Rock Co. (see Appendix). The National Cooperative Highway Research Program, Transportation Research Board, Project 9-7 FY '93 for this year, more than alludes to the use of SPC, in particular, phase III (see Appendix).

It is far preferable for organizations to opt for a program of continuous improvement without external pressure. The benefits of SPC are many and varied and be obvious to most; the slide suggests some of them. We have an opportunity to gain a competitive edge industry-wide.

There is fierce competition in the market place; there are a limited number of suppliers of a particular product, and the market share means that eventually, one or more of these suppliers will go out of business. Which company will it be? How will that decision be made? What can be done to influence the situation? I would urge the ISSA to take an active role in TQA for its members.

Quality Costs

It is a matter of some concern that for an unacceptably high number of USA and European organizations, the true level of quality costs is not known. Companies often continue in operation on the basis that they have made a profit, but the waste entailed in providing this profit is not known. In the same vein, many organizations have stated that they do not intend to implement programs such as SPC because they cannot afford to buy new measuring equipment. This is a false economy. The money that has to be spent up front will result in substantial savings later.

Summary

* SPC is the use of statistical methods in monitoring and improving any activity.
* SPC should be promoted because of its benefits rather than because the customer requires it.
* True quality costs should be determined.
* Quality is customer satisfaction.
* SPC and SQC are not the same thing.

It has been stated that a key aspect of SPC is to obtain predictable processes that produce consistent results. In order to decide whether a process is predictable or not, one needs data. A good starting point, therefore, is to look further at the data; what form it takes and how it can be handled and represented. The hard part is deciding what data is pertinent to our industry.

FIELD COHESION TESTER CORRELATION STUDY

PART I

Three slurry seal systems were used to evaluate the validity of the field cohesion tester. 2" samples were measured using both the standard and field cohesion testers as well as a 9" sample to better simulate the larger surface area encountered in the field.

The first system consisted of an unmodified emulsion and a southern Ohio Type II Dolomite 0-#4. System number 2 is a 1.4 modified emulsion and the same Ohio Type II Dolomite 0-#4 as used in the first system. The third system is a 1.2 modified emulsion and a New York Type II Dolomite 0-#4. All three emulsions use the same base asphalt.

RESULTS (Ambient)

SYSTEM I:
.75pc-8-12

	10′	20′	30′	60′
Standard Cohesion Tester	11.5	12.0	13.2	20.0
Field Cohesion Tester	11.8	12.0	13.2	18.5
9" Field Cohesion Tester	-	-	20.0	22.0

SYSTEM 2:
.75pc-8-12

Standard Cohesion Tester	20.0	21.2	22.2	23.0
Field Cohesion Tester	19.0	20.0	21.0	22.6
9" Field Cohesion Tester	-	-	20.0	23.0

SYSTEM 3:
.75pc-8-12

Standard Cohesion Tester	15.5	17.5	20.2(s)	20.0
Field Cohesion Tester	15.0	17.6	20.9(ns)	19.2
9" Field Cohesion Tester	-	-	18.5	22.0

PART II

The following data is a comparison between field cohesion and lab cohesion of a Ralumac system using Plum Run "A" aggregate. The formulation for both tests were the same at .58% Portland Cement, 7.4% mix water and 11.4% asphalt emulsion.

Test conditions

LAB: Confined and unconfined samples made in single and double layers @ 72°F

FIELD: A double layer @ 65°F, sunny

	10′	20′	30′	60′
Single layer unconfined	9.5	15.8	18.5	18.0
Single layer confined	12.0	16.0	17.5(s)	18.5
Double layer unconfined	9.5	15.0	16.2	20.0
Double layer confined	12.0	16.0	17.5(s)	20.0
Field C.T. double layer	15.0*	14.2*	18.4*	16.2*

(s) = spin * = average of 9 points

CONCLUSIONS

The data from the lab shows little difference between confined and unconfined samples. Confined samples seem to give higher cohesion value until the sample is completely "set". The values at 1 hour are the same. A double layer seems to yield slightly higher cohesion values.

The data extracted from the field cohesion tester doesn't seem to directly correlate with the lab data. The values at 20′ and 30′ are similar but the value drops off at 1 hour from 20 to 16.2. This could be due to a faster set in the field. The surface temperature averaged 79°F. Direct sunlight and a moderate breeze seem to quicken the set time of the material. A slurry that is completely set will be harder, give less resistance to the foot of the cohesion tester, thus yielding a lower value.

PART III

The following are field cohesion results from Ergon Technical Development in Jackson, MS. The test data was collected from 3 different job sites. A Type II Vulcan Iuka aggregate was used for all three. The mix formula for the 3 systems was .75% cement, 10% mix water and 12% asphalt cement.

The field results are tabulated from an average of three points (right, center, left):

Tallahassee Co., MS #1 Surface Temp. 23°C Mix Temp. 20°C

Lab (Ambient)	30′	60′
	24	25
VAN (25°C)		
	22	23

FIELD COHESION TESTER

	#1		#2		#3		#4	
	30′	60′	30′	60′	30′	60′	30′	60′
Right	17	21	19	25	22	23	23	22
Center	20	23	19	23	19	21	20	21
Left	20	22	21	26	22	23	22	20
Average	19	22	19.7	24.7	21	22.3	21.7	21
AVERAGE OF 4	20.3	22.5						

Jasper Co., MS Surface Temp. 24°C Mix Temp. 19°C

Lab (18°C)	30′	60′
	24	25
VAN (24°C)	25	26

FIELD COHESION TESTER

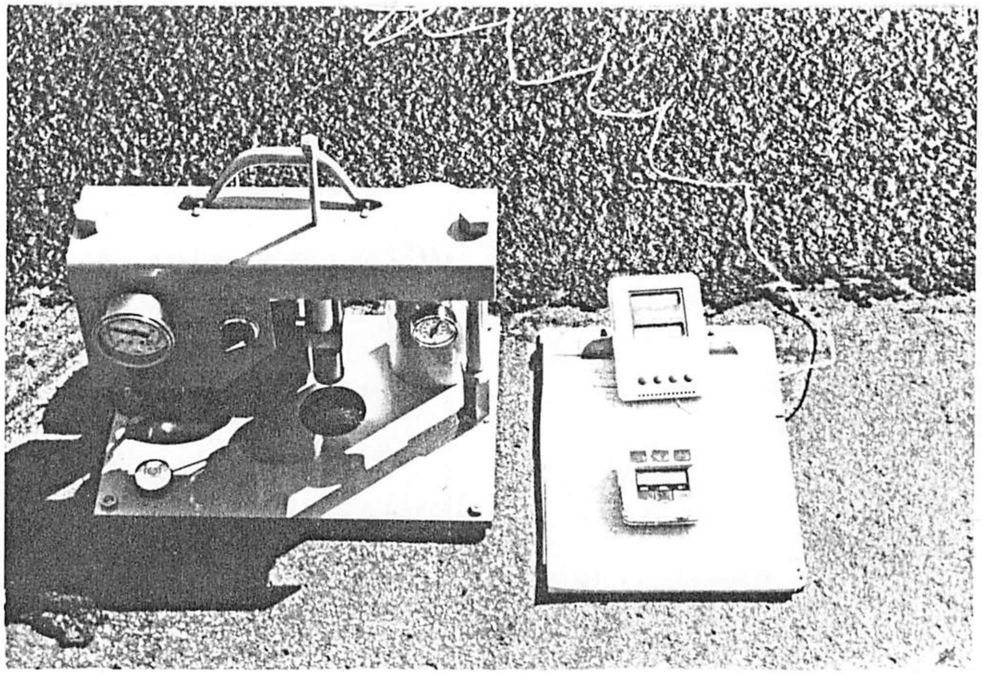
	#1		#2		#3		#4	
	30′	60′	30′	60′	30′	60′	30′	60′
Right	26	25	25	25	23	26	22	23
Center	26	26	24	25	27	25	24	24
Left	25	24	24	26	24	24	24	24
Average	25.7	25	24.3	25.3	24.7	25	23.3	23.7
AVERAGE OF 4	24.5	24.8						

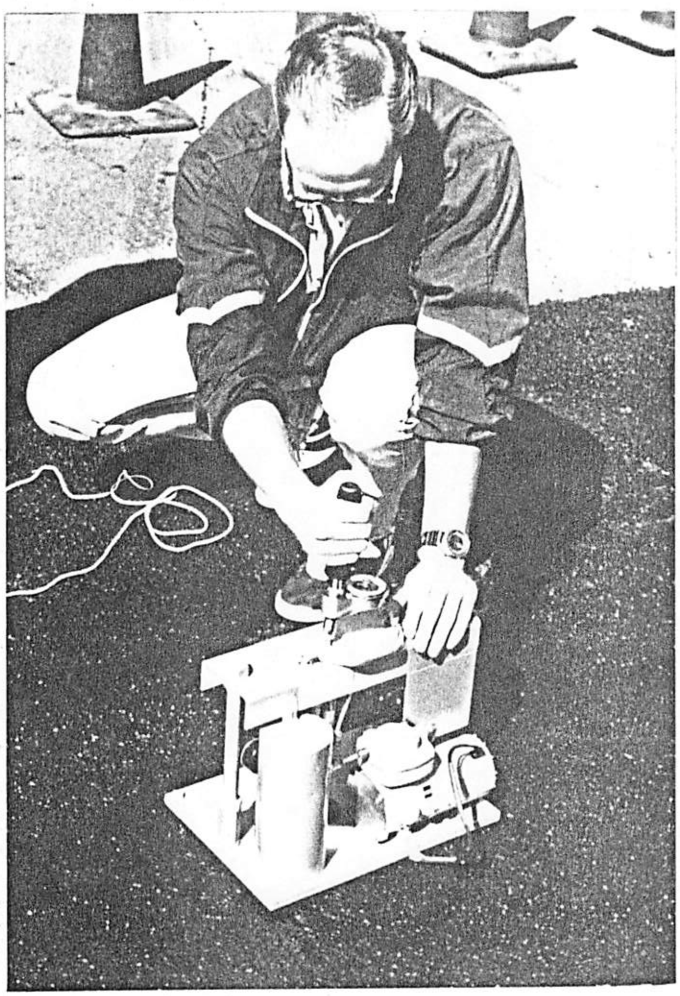
Tallahassee Co., MS #2 Surface Temp. 23°C Mix Temp. 20°C

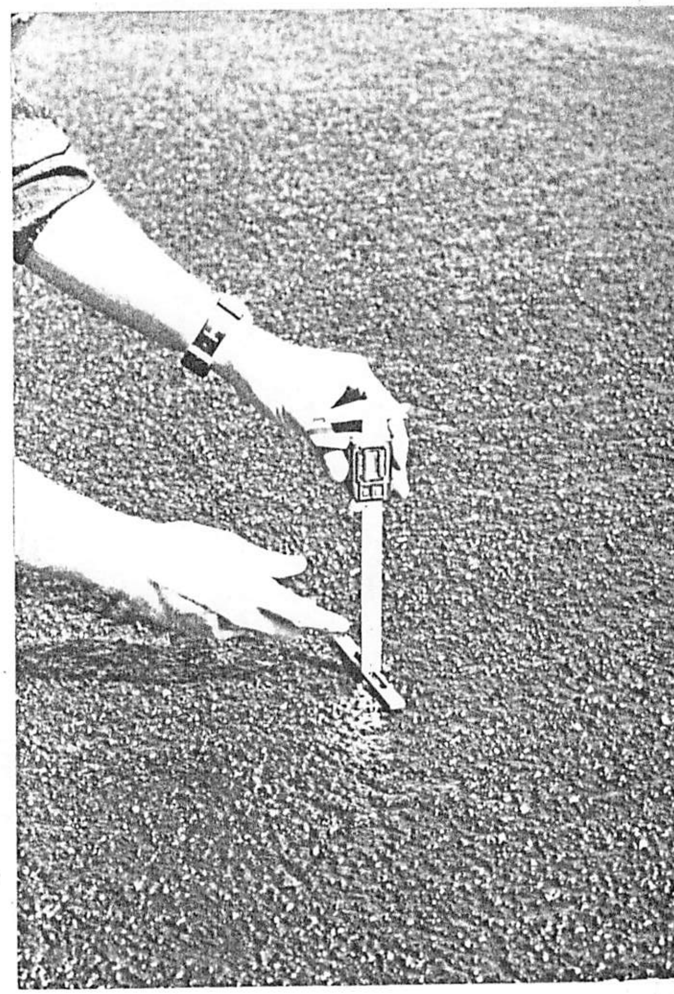
	30'	60'
Lab (17°C)	24	25
VAN (22°C)	22	24

FIELD COHESION TESTER

	#1		#2		#3		#4	
	30'	60'	30'	60'	30'	60'	30'	60'
Right	18	23	21	20	21	24	22	23
Center	20	23	23	24	22	24	22	26
Left	20	21	19	22	21	23	19	22
Average	19.3	22.3	21	22	21.3	23.7	21	23.7
AVERAGE OF 4	20.7	22.9						







Conclusion;

The Field Cohesion Test looks as if it will correlate with the laboratory version. Standard cohesion values with a +/-2 variation make this tool a potentially valuable instrument in assessing a small part of a Quick Traffic specification. Much more data should be collected in the form of a capability study to insure the validity of the instrument.

QC/QA and Total Quality Assurance are here (appendix, Region One QA/QC Workshop). The use of SPC is just starting in the asphalt industry and the opportunity to get ahead of the trend is now. It would benefit our industry to develop SPC programs using pertinent test methods before we are included in arbitrary programs that do not understand our products. There is a need to develop TQA with meaningful results so that the ISSA may "influence the influencers".

GRANITE ROCK WINS A BALDRIDGE

AGC MEMBER WINS CONSTRUCTION'S FIRST BALDRIDGE QUALITY AWARD

An innovative, customer-oriented California firm that is both a building material manufacturer and a paving contractor is the construction industry's first winner of the prestigious Malcolm Baldridge National Quality Award.

"We're still sky-high around here," said Greg Diehl, marketing services manager of Granite Rock Company, the day after the 92-year-old Watsonville firm received a call from U.S. Commerce Secretary Barbara Hackman Franklin with the news that Granite Rock was a winner on its fifth try for a Baldridge.

The win put Granite Rock in rarefied company. Since its creation by Congress in 1988, Baldridge awards have gone to only 17 companies, and just three of those were small businesses.

Granite Rock Co-Presidents (from left) Steve Woolpert and Bruce Woolpert.

For Granite Rock, winning the Baldridge is the culmination of a long history of dedication to total quality management. The dogged determination by the brother team of Bruce W. and Stephen G. Woolpert, co-presidents of the company, has resulted in a devotion to quality management that has accompanied consistent increases in the company's market share.

Granite Rock was organized by Arthur F. Wilson, grandfather of the Woolpert brothers, and is still privately owned by family members.

From 20 locations within a 90-mile radius of Watsonville, the company is a major supplier of construction materials for building and roadway construction as well as a general engineering contractor specializing in asphalt and roller compacted concrete paving.

The company is a member and active participant in AGC activities, according to AGC of California Executive Vice President Kenneth L. Gibson, who says "they participate at all levels." In 1988, AGC of America filed a friend-of-the-court brief in support of the company, urging the U. S. Supreme Court to grant a review of a Court of Appeals ruling that the employer had to arbitrate the union's claim that the employer had violated an "implied covenant" that forbade the employer to establish a double-breasted operation. The Supreme Court did not grant the review.

In making the award to Granite Rock, the Baldridge Committee said that the company had increased market share and revenue per employee by competing on product quality and service. The Committee also noted the company's unconditional guarantee, its high level of spending on training (13 times the average for construction, according to the committee), and its use of computerized statistical process control to reduce process variability and increase reliability.

Highlights of Granite Rock's quality management include the following:

☐ It's emphasis on safety has resulted in a $2 million annual savings in insurance premiums.

☐ Customers receiving monthly invoices from the company are able to mark through and withhold payment for any item that did not completely satisfy them.

☐ After a polling of its customers revealed a need for quick and convenient pick up of crushed rock orders at odd times, Granite Rock developed a card activated system usable around the clock. With the automated system, a customer's truck can be loaded in an average of nine minutes.

☐ The average employee receives 37 hours of training in technical and non-technical areas every year after the development of a individual professional development plan (IPDP) in coordination with his or her supervisors.

Like other Baldridge winners, Granite Rock has agreed to share its quality management strategies. For a fee, it intends to begin offering day-long tours of its facilities and lectures on how it became an exemplary quality company and winner of the nation's most coveted quality award. The first session is tentatively scheduled for December.☐

—By Bill Hickman, *secretary to AGC's Quality in Construction Committee*

Project 9-7 FY '93

Field Procedures and Equipment to Implement SHRP Asphalt Specifications

Research Agency: Contract Pending
Principal Invest.:
Effective Date: (42 Months)
Completion Date:
Funds: $1,000,000

Researchers in the asphalt area of the Strategic Highway Research Program (SHRP) are fulfilling their goals of producing performance-related specifications for asphalt binders and mixtures. These specifications will be accompanied by specific procedures and equipment for applying the SHRP mixture design and analysis system. The proposed specifications, which incorporate findings from a number of previous studies including NCHRP Project 9-6(1), "Asphalt-Aggregate Mixture Analysis System (AAMAS)," are expected to significantly advance asphalt technology, by relating improved asphalt binders and mixture design with actual field performance.

Interest in products from the asphalt area of SHRP is growing throughout the nation, and AASHTO member departments are actively gearing up for SHRP implementation. The AASHTO Task Force on SHRP Implementation has targeted SHRP's asphalt products as one of their early priorities. Members of the AASHTO Highway Subcommittee on Materials are evaluating more than 20 specific products in the asphalt area. A pooled-fund study is being formed to assist states in purchasing the necessary laboratory test equipment. To fully implement SHRP recommendations, however, industry must be involved and will need the knowledge and tools to comply with the new requirements. User-producer groups are forming on a regional basis, involving highway agencies, contractors, and materials manufacturers and suppliers. Information presented to these groups by SHRP researchers and staff is encouraging awareness of and support for these new systems and specifications.

Significant improvements in binders, test equipment and procedures, analysis of test results, and specifications will provide mixtures for greater performance. However, to realize these improvements, highway agencies must change the way asphalt pavement materials are designed and specified, and the asphalt mixtures placed and compacted on the roadway must comply with the specifications. How can this be ensured? What specific Q/C Q/A equipment and procedures must be used at the asphalt plant and the paving site, and what statistical tolerances are necessary on these procedures? What controls must be placed on the asphalt binder, the aggregates, any additives or modifiers, the process, and the final mixture? How can appropriate compaction be assured? How often and by whom should these Q/C Q/A procedures be accomplished? What training is needed and who will be qualified to take the mixture design and analysis system from the laboratory to the field?

Field control procedures are being developed under the SHRP A-001 contract to assist field technicians in adjusting mixture design and monitoring production; however, this effort is limited to the adaptation of previously developed steps. Needed is a major research effort focusing specifically on field implementation of SHRP asphalt specifications.

The objectives of this research are: (1) to establish comprehensive procedures and, if required, develop equipment for quality control/quality assurance at the asphalt plant and laydown site to ensure that asphalt pavements meet the SHRP performance-related specifications and (2) to develop a framework for a training program for qualifying technicians to accomplish the Q/C Q/A field procedures developed.

Accomplishment of the objectives will require at least the following tasks: **Phase I** — (1) Review and analyze SHRP performance-related specifications and research results, including SHRP recommendations for field control procedures, as well as data from SPS-9 pilot projects. (2)

Review and evaluate other applicable research activities in asphalt mixture Q/C Q/A. (3) Review Q/C Q/A issues and relationships in related industries or industries with similar control or production procedures to identify applicable concepts. (4) Recommend the appropriate level of control, i.e., tests or other measures, for the quality of materials delivered to the asphalt plant, including asphalt cement, aggregate, modifiers, and additives. (5) Propose a statistically based experimental plan to collect field data that can be used to develop procedures to verify, accept, and control the asphalt mix. Verification will ensure the mix produced by the plant and laid in the field meets the SHRP performance-related specifications. (6) Submit an interim report that presents the results of Tasks 1–5 and describes in detail the work proposed for the remaining tasks.

Phase II — (7) Conduct the series of field experiments approved in Phase I. (8) Based on data collected in Task 7, establish the allowable tolerances and variabilities of the various test results. The test procedures must produce results in a timely manner. (9) Based on the results of Task 8, identify the need for modified or additional field testing equipment, and, if needed, develop the equipment in accordance with NCHRP approval.

Phase III — (10) Finalize Q/C Q/A procedures. These procedures shall include a family of statistically based sampling and test plans appropriate for SHRP mixture design levels for various levels of service (based on traffic volume). (11) Develop guidelines using Q/C Q/A procedures that define the circumstances when mix adjustments, which may be made in the field, are applicable versus those circumstances that require a complete new mix design. (12) Develop guidelines for implementation of these research results. (13) Design a framework for a training program for qualifying technicians. (14) Submit a final report documenting the entire research effort.

REGION ONE QA/QC WORKSHOP
November 30 - December 2, 1992
Springfield, Massachusetts

Monday, November 30, 1992 — **Moderator Bruce Hosley, FHWA**

Time	Topic	Speaker
12 noon	Registration	
1:00 pm	Welcome	Michael Swanson, MAHD & Donald Hammer, FHWA
1:30 pm	FHWA National Perspective on QA/QC	William Weseman, FHWA
2:00 pm	Introduction to QM Concepts	Donald Tuggle, FHWA
2:45 pm	Quality Control in the Concrete Paving Industry	Clint Solberg, ACPA Madison, WI
3:15 pm	BREAK	
3:30 pm	Industry Perspective	Charles Potts, APAC
4:00 pm	Statistical Principles for QA/QC Programs	Charles Hughes, Consultan: Virginia
5:00 pm	ADJOURN	

Tuesday, December 1, 1992 — **Moderator Bob Barton, MaCAPA**

8:00 am	QA/QC Implementation - MN Process Control/Technician Certification Program	Gerald Rohrback, MNDOT
8:45 am	QA/QC Implementation - OR Price Adjustment & Acceptance Criteria	Wayne Cobine, ORDOT
9:30 am	QA/QC Implementation - OK Program Implementation	S.C. "Pete" Byers OKDOT
10:15 am	BREAK	
10:30 am	QC in the Aggregate Industry	David Jahn, American Aggregate, Dayton, OH
11:00 am	QC in the Concrete Industry	Lester "Cappy" Burnside Consultant, WV
11:30 am	QC in the Hot Mix Asphalt Industry	Robert Joubert, Asphalt Institute, MA
12 noon	LUNCH	

Moderator Walter Kudzia, FHWA

1:30 pm	Round Robin Presentations of NE States QA/QC Programs	
	New Jersey	Henry Justus, NJDOT
	New York	James Murphy, NYSDOT
	Puerto Rico	Al Lopez, FHWA
	Massachusetts	Leo Stevens, MAHD Kenneth Ware, Bechtel Parsons CA/THT
	New Hampshire	Alan Rawson, NHDOT
	Vermont	Richard Haupt, VAOT
	Maine	Ted Karasopoulas, MDOT
	Connecticut	Dr. Charles Dugan, CTDOT
	Rhode Island	Colin Franco, RIDOT
5:00 pm	ADJOURN	

Wednesday December 2, 1992 — **Moderator Roger Macdonald, MAAPA**

8:00 am	Development of QA Specs. - AASHTO Task Force for QA/QC Guide Specs. and WASHTO Guide Specs.	Donald Tuggle, FHWA
8:30 am	Partnering	Thomas Schmitt, AZDOT
9:30 am	Partnering on the Central Artery	Larry Bonine, Bechtel Parsons, CA/THT
10:00 am	BREAK	
10:15 am	Innovative Contracting Procedures	William Weseman, FHWA
10:45 am	Contractors Perspective	James Marold & Robert Turner, Lane Const. Co.
11:30 am	Closure/Wrap Up	Donald Tuggle/Moderators
12 noon	ADJOURN	

Directly