Research Report
KTC-08-19/SPR347-07-1F

KENTUCKY TRANSPORTATION CENTER

QC/QA: EVALUATION OF EFFECTIVENESS IN KENTUCKY

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Final Report
KTC 08-19/SPR347-07-1F

QC/QA: Evaluation of Effectiveness in Kentucky

by

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<tr><td colspan="4">16. Abstract Quality control and quality assurance in the highway industry is going through a cultural shift. There is a growing trend toward using the contractor data for acceptance and payment purposes. This has led to serious concerns about conflicts of interests. The question remains: are there adequate safeguards in place? To address these concerns, a number of asphalt and concrete QC/QA projects in Kentucky were examined and statistical analyses were conducted. This report presents a summary of findings and recommendations. Generally speaking, the Kentucky experience revealed that the QC/QA system is working well, and the agency's random inspection data when compared to the contractor reported QC data showed similar trends. However, it is critical for the verification regime to be truly independent.</td></tr>
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EXECUTIVE SUMMARY

This is the final report for the research project "QC/QA: Evaluation of Effectiveness (KYSPR-07-347)". The project was approved in July 2006, and it concluded on June 30, 2008. The purpose of the project was to re-visit the experience of Kentucky with the QC/QA specifications. This was initiated because the QC/QA specifications represent a major departure from traditional highway department specifications. The study included a careful review of project data from a group of representative projects, and it included some one-on-one as well as group interviews with the Cabinet staff as well as contractor staff. Finally, the study included a nationwide survey of highway agencies regarding their experience with the implementation of QC/QA specifications. The information generated in this study offers a series of specific recommendations for implementation. By and large, the Kentucky Transportation Cabinet and the construction industry seem to have a positive experience with QC/QA specifications. The statistical examination of Kentucky QC/QA project data revealed that, for the most part, the current inspection regime is tracking the projects adequately. It also revealed that KYTC inspection data and contractor reported data are not very different. The interviews and surveys reveled that all agency independent tests must be truly independent. That is, independent testing personnel as well as independent testing equipment. All interviewees agreed that the Kentucky Transportation Cabinet's project inspection capabilities must be strengthened. Finally, all laboratory and field specimens must be better protected and their chain of custody must be fully documented.

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Chapter 1 - Introduction

1.1 Background and Significance of Work

In recent years the state of Kentucky has adopted Quality Control/Quality Assurance (QC/QA) specifications for its highway construction projects. These specifications are gradually gaining acceptance and many other state highway agencies across the country have implemented them as well. Generally speaking with a QC/QA specification, the contractor is in control of the day-to-day testing (Quality Control) while the DOT performs a broad oversight and verification testing (Quality Assurance). Under such a system, contractor data may be used for payment so long as there is good agreement between DOT and contractor data. The goal of this type of specification is to produce a better quality product by allowing the contractor to have more control over the construction process, thereby giving the contractor better knowledge of the quality product as it is being produced. It also allows for innovations to be implemented in short order. This is because the contractor is more involved in improving the efficiency of the construction processes in comparison to the traditional quality control methods, in which DOT personnel conducted all QC/QA testing and inspections.

After several years of experience with QC/QA specifications in Kentucky, a research project was commissioned in order to find out whether the QC/QA program has been effective, and whether it has resulted in good quality construction. To facilitate answering these questions, this research project conducted numerous surveys and interviews with KYTC personnel and state contractors. The research team conducted detailed statistical analysis on data provided by KYTC, and studied the QC/QA specifications of other states aimed at identifying specific lessons learned from the experience of other states. Additionally, the research team studied a large number of QC/QA project data in order to compare data trends as reported by the contractors versus those verified by the KYTC.

1.2 Objectives of the Study

With the exception of asphalt and concrete pavements, most QC/QA bid items are still relatively new in the state of Kentucky. Some of the current QC/QA bid items are still in an experimental stage. With this in mind, the following research objectives were set forth:

- Review the QC/QA experience in Kentucky through interviews, surveys, and project data;
- Evaluate the effectiveness of the current KYTC QC/QA specifications by statistical analysis; and
- Study the QC/QA specifications of Kentucky and other states and identify lessons learned from their experience.

The first portion of this report describes the findings of many interviews with the KYTC staff. The second portion summarizes detailed statistical analysis of the hot mix asphalt and concrete inspection data derived from the KYTC-KMIMS database. The third portion of the report summarizes the survey results received from the state DOTs across the nation.

1.3 History of Kentucky QC/QA

The Kentucky Transportation Cabinet's QC/QA program is a dynamic set of specifications, and it has gone through several cycles of modifications from its inception. Materials and procedures addressed by the program are the result of several years of continued efforts by the KYTC Construction and Materials Division personnel as well as the highway materials and construction industry. The development of the hot mix asphalt specification, for example, began in the mid 1980's while the development and implementation of a complete embankment specification is presently underway. Currently, Kentucky QC/QA specifications extend into the following construction areas:

1. Hot Mix Asphalt (HMA);
2. Concrete Pavements;
3. Soil Embankments;
4. Paint Striping; and
5. Bridge Painting.

Prior to the QC/QA program, the specifications in Kentucky were initially designed in such a way that most of the responsibility of Quality Control and Quality Assurance rested fully on the shoulders of Kentucky Transportation Cabinet personnel. Construction inspectors at the District level were charged with collecting material samples at the intended frequency and were responsible for seeing that materials were placed according to specifications. The District Materials Engineer (DME) and his or her staff were further responsible for testing the properties of those materials collected by construction staff, and approving or rejecting them for payment purposes.

The Kentucky QC/QA program was implemented in the mid 1990's. In this system, highway contractors were charged with handling the functions of Quality Control (day-to day process control testing) while the Transportation Cabinet personnel performed random tests in an effort to assure quality of the construction and the materials (Quality Assurance). For example, the contractor would be required to obtain four asphalt samples (cores) per 1000-ton sublot on for QC purposes, and the KYTC personnel would be required to obtain one random asphalt sample out of the same sublot for QA purposes.

An additional level of quality check is in place in Kentucky, and it is called independent quality assurance. This is an umbrella validation function; a way to check the Quality Control work performed by the contractor as well as the Quality Assurance work performed by the KYTC inspector or other designee. In theory, this function is to be performed on a random basis by KYTC Central Office Construction personnel. Setting the frequency of the quality assurance testing can be a challenge; it must be effective and efficient.

1. 4 Reasons for Adapting QC/QA

The Kentucky Transportation Cabinet has set up the QC/QA program to fulfill several objectives. Under a QC/QA regime, the DOT and the contractor share the same objective: to produce a quality construction at the lowest cost possible. The primary QC/QA objectives of the DOT include the following:

1. Improve the quality of the materials and construction, and reduce the life cycle costs for the facilities involved;
2. Redirect the responsibility for day-to-day quality control on projects to the contractor;
3. Reduce the potential disputes between the DOT and its contractors; and
4. Enhance the construction delivery schedule and the Cabinet's effort on quality management.

1.5 Kentucky's Current QC/QA Process

Even though Kentucky started the QC/QA for HMA in 1997, the overall practice of QC/QA is still limited in Kentucky. Details of the QC/QA practices and procedures can be found in the Kentucky standard specification. In addition to the HMA, there are special notes on QC/QA for other construction items. Table 1.1 shows various special notes for QC/QA specifications.

Table 1.1 Special Notes QC/QA Specifications

Designation of Special Notes	Material
10V	Aggregate
10E	Class P Concrete
10R	Structural and Non-Structural Concrete

Kentucky's current QC/QA procedures start with contractor's processes for quality control. This is followed by acceptance of product by the Cabinet. A brief description of contractor's process control and DOT's acceptance procedure is described below.

1.5.1 Kentucky's Contractor Processes for QC

Kentucky's typical process for a contractor's quality control program can be summarized and explained as follows.

- Quality Control Plan (QCP): The QCP includes the testing and evaluation programs, staffing, material handling and construction procedures, calibration and maintenance of equipment, production process control, and sampling and testing required by contract documents.
- Proper Documentation: Proper documentation includes maintaining records for all QC activities and tests performed. Documentation also includes the work of subcontractors and suppliers, and it requires approval by the Department.
- Adequate Personnel: The contractor staff must be available until the project is complete, and the contractor is expected to provide a Quality Control Plan with a Quality Manager and adequate qualified personnel to carryout the plan.

1. 5.2 Kentucky's Contractor Requirements for QC/QA

Kentucky, like other states, has set up certain qualifications and standards which contractors must meet in order to participate in a QC/QA project. The following are some typical requirements that the contractor must fulfill. For example:

- A producer/supplier is to be selected who conforms to specification requirements.
- Qualified technicians are to be provided for the appropriate applications.
- An AASHTO accredited or Kentucky Transportation Cabinet qualified laboratory facility is also to be provided.

In addition to qualifications met prior to a job, contractors have a number of job-site requirements to fulfill; these may include such items as collecting concrete trip tickets, which should be collected for every load and include information on the mix characteristics such as age of mix, mixing revolutions, and discharge time.

Contractors are also expected to have technicians on site who are obtaining samples and providing visual inspections. The contractor must also have an adequate amount of approved equipment in order to test samples at the necessary frequencies.

1.5.3 Acceptance Procedures

The State Engineer/Inspector is expected to conduct verification testing, using qualified personnel, as a check against the contractor reported data. The Engineer determines, according to Kentucky specifications, when the Contractor is to perform random sampling and testing. The Engineer also notifies the Contractor immediately prior to conducting required random sampling and testing.

The Engineer is expected to test at a minimum frequency of one acceptance test per lot. The Engineer has the right to increase the frequency of testing when it is deemed necessary. The Engineer performs verification testing on independent samples from the same batch and location as the Contractor's sample and promptly compares results. Additionally, the Engineer may select any portion of the product at any time for more testing. KYTC may perform the verification test on the Contractor's equipment or on the Department's equipment. Provided that the differences are within the KYTC-specified tolerances, and the results compare favorably with the other sublots' results, KYTC will use the Contractor's test values to compute the appropriate lot pay factor.

When the verification test results differ from the Contractor's reported test data by more than the KYTC-specified tolerances, the discrepancy must be resolved and fully documented along with any additional verification test results. A dispute resolution process is utilized to verify the final acceptability of the finished product.

1.6 Recent Considerations

The Kentucky Transportation Cabinet has experienced several cycles of large retirement among its staff in recent decades. Retirement incentives coupled with market forces has led to unprecedented vacancies in construction and other divisions. Many of the vacated positions have not been and are not expected to be filled, leaving the KYTC with the challenge of having to do more with less.

To deal with the shortage of personnel, KYTC has implemented a program to employ Consultant Technicians (CT). Under this program, consulting engineering, testing, and inspection firms are contracted to perform some or all of the functions which are typically performed by the KYTC inspectors and materials testing personnel. Consulting firms are selected on the basis of the lowest bid submitted, much like primary construction contracts. Once a bid is accepted by the Transportation Cabinet, a two year commitment is required of the consulting firm to supply the Cabinet with qualified inspectors at a preset rate. Depending on the size and nature of a given project, consultant technicians may work independently, with other CT personnel, with KYTC personnel, or any combination thereof.

Although it is not a rule, it is not uncommon for general contractors to also subcontract their respective responsibilities for Quality Control and inspection to independent firms. It is critical to a have a firewall in place so that the same consulting firm does not end up working for the contractor and the Cabinet at the same time on the same project. To avoid the potential for conflicts of interest, the Transportation Cabinet defined a region-based area of operation for consulting firms working on KYTC projects. Under this system, multi-county regions of Kentucky were delineated by KYTC so as to define boundaries within which consultants could perform work on behalf of one party or the other, but not both within a given region (Table 1.2). For example: Consultant X could not perform Quality Control work for General Contractor Q in Kenton County while performing Quality Assurance work for KYTC in Fleming County. This system allows the consultant to perform work in multiple regions for multiple parties so long as he or she does not perform conflicting inter-regional work.

Table 1.2: Regional KY-Permitted Consultant/Technician Work Areas

Two-District Regional Work Areas	Area	Counties					
	1	Ballard	Calloway	Carlisle	Crittenden	Fulton	Graves
		Hickman	Livingston	Lyon	McCracken	Marshall	Trigg
	2	Caldwell	Christian	Daviess	Hancock	Henderson	Hopkins
		McLean	Muhlenberg	Ohio	Union	Webster	
	3	Allen	Barren	Butler	Edmonson	Logan	
		Metcalfe	Monroe	Simpson	Todd	Warren	
	4	Breckinridge	Grayson	Green	Hardin	Hart	Larue
		Marion	Meade	Nelson	Taylor	Washington	
	5	Bullitt	Franklin	Henry	Jefferson		
		Oldham	Shelby	Spencer	Trimble		
	6	Boone	Kenton	Campbell	Bracken	Pendleton	Grant
		Owen	Gallatin	Carroll	Harrison	Robertson	
	9	Bath	Boyd	Carter	Elliott	Fleming	
		Greenup	Lewis	Mason	Nicholas	Rowan	
	7	Anderson	Bourbon	Boyle	Clark	Fayette	Garrard
		Jessamine	Madison	Mercer	Montgomery	Scott	Woodford
	8	Adair	Casey	Clinton	Cumberland	Lincoln	
		McCreary	Pulaski	Rockcastle	Russell	Wayne	
	10	Breathitt	Estill	Lee	Magoffin	Menifee	
		Morgan	Owsley	Perry	Powell	Wolfe	
	11	Bell	Clay	Harlan	Jackson		
		Knox	Laurel	Leslie	Whitley		
	12	Floyd	Johnson	Knott	Lawrence		
		Letcher	Martin	Pike			

Chapter 2 - Literature Review

2.1 Search Methodology

It was important to closely study the previous work conducted in this area. The literature study included a review of relevant bibliographic contents of the collected articles and reports to determine if there are any lessons to be learned that might be applicable to Kentucky. The information found in the literature review is described in the four categories below:

- Contractor Performed Quality Control
- Current QC/QA Specifications
- Current QC/QA Issues
- Recent QC/QA Studies

2.1.1 Contractor Performed Quality Control

This area of the literature research revealed how most DOTs have decided to transfer the responsibility for standard quality control functions to their contractors, with only quality assurance performed by the DOTs (Hancher et al, 2002). Contractor Performed Quality Control (CPQC) on Kentucky Transportation Cabinet (KYTC) projects is a research report that discussed the implementation of CPQC on Hot Mix Asphalt (HMA), concrete, soil embankment and subgrade, pavement stripping, and bridge painting by the KYTC (Hancher et al, 2002). Research for this study was based upon a literature review, a nationwide survey, data from the KYTC's KMIMS database, and a separate survey specific for Kentucky district engineers and highway contractors.

The nationwide survey sought to find the scope of QC/QA specification and their changes to redefine the responsibility of agencies and contractors. The survey also asked the respondents to evaluate their QC/QA programs, indicate its major advantages and concerns, and identify the factors influencing the implementation of their programs. The DOTs responded that the major advantages were that contractors are responsible for their own products, gaining knowledge by contractors, and improved quality. The contractors responded that the major advantages were that contractors are more in charge of controlling quality of their product, improved schedule, and improved quality. On the other hand, the top concerns that the DOTs expressed were: 1) inability to effectively check the contractor test data, 2) insufficient certified technicians. The contractor's top major concerns were: 1) capability of technicians, 2) the cost of quality control, 3) lack of trust on the part of the DOT, and 4) lack of training for resident engineers and contractor personnel.

2.1.2 Current QC/QA Specifications

The literature search conducted by this research effort described herein revealed that there are various QC/QA practices around the nation. Elmore et al's (1997) "Qualifying Items of Work for End-Result specifications," report was aimed at reviewing the Texas Department of Transportation (TxDOT) standard specifications in order to recommend suitable candidates for further development and potential implementation. End-result specifications, also identified as performance-based specifications in this report, are currently being used by the Texas Department of Transportation (TxDOT) for hot-mix asphalt and concrete pavements.

Solaimanian et al's (1998) "Develop a Methodology to evaluate the effectiveness of QC/QA specifications (Phase II)" discusses the implementation of statistically based quality control/quality assurance (QC/QA) specifications for hot mix asphalt concrete pavements by the TxDOT since the early 1990s. These specifications have been revised and improved based upon feedback of parties involved as well field experience. The use of the QC/QA specifications led to the development of performance-based specifications (PRS). Performance-based specifications are founded on the pavement performance, which is predicted through prediction models and the relationship between materials and construction variables with pavement performance.

Method specification directs the contractor to use specified materials in definite proportions and specific types of equipment and methods to place the material. Each step is directed by a representative of the highway agency. This type of specification has been used for many years by transportation agencies to control quality. Such specifications typically are applied to materials for which significant lapses in quality would require removal and replacement (Benson, 1995). Method specification, in theory, should reduce job delays, contract claims, and escalation in future bid prices by ensuring that the work is done right the first time. However, this type of specification has two important disadvantages. First, it stifles innovation and competitiveness by prescribing exactly how the work is to be done in great detail, and second it requires the full-time presence of experienced field personnel for proper enforcement (Benson, 1995).

QC/QA specifications can designed to combine the desirable features of end result specifications and methods specifications. The contractor is responsible for QC (quality control as related to process control), and the highway agency is responsible for acceptance of the product (Burati et al, 2003). The goal of a QC/QA specification is to relate the measured quality characteristics to the anticipated performance of the materials or construction. The Transportation Research Boards (TRB) Transportation Research Circular Number E–C037, "Glossary of Highway Quality Assurance Terms," defines performance related specifications as, *"QA specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance."* These characteristics (for example, air voids in AC and compressive strength of portland cement concrete [PCC]) are amenable to acceptance testing at the time of construction (Burati et al, 2003).

2.1.3 Current QC/QA Issues

Some very important issues have been raised which could affecting the view of state DOTs toward QC/QA specifications. The most significant has been reports of some contractor fraudulent activities, such as reporting fraudulent data (Crumpacker, 2008). The concern is that the potential for fraudulent data is not fully addressed. The Office of the Inspector General (OIG) OIG is starting to see an increase in quality control testing fraud. Such activities may include: a contractor misrepresenting the quality control data in order to qualify for full/bonus pay, or avoid penalty, or avoid production shutdown, or avoid removal of deficient material (Crumpacker, 2008). OIG recently has investigated cases in which contract employees manipulated results from quality control tests to falsely earn contract incentives or avoid potentially costly project delays. Jim H. Crumpacker, OIG's director for National Investigative Programs and Operations, pointed out that the following actions should raise concern about quality control fraud (Crumpacker, 2008):

1. Contractor employees regularly taking or labeling QC samples away from inspector oversight;
2. Contractor insisting on transporting QC samples from the construction site to the lab;
3. Contractor not maintaining QC samples for later quality assurance (QA) testing;
4. Contractor challenging results or attempting to intimidate QA inspectors who obtain conflicting results;
5. Photocopies of QC test results where originals are expected; and
6. Alterations or missing signatures on QC test results.

The chronic shortage of DOT staff may contribute to this problem by restricting the amount of DOT qualified technicians available to oversee various construction jobsites and prevent these fraudulent activities from occurring. In order to ensure better project oversight, state DOTs may have to resume a more active role in project oversight (Crumpacker, 2008).

2.1.4 Recent Studies

The US Department of Transportation's Federal Highway Administration Office of Infrastructure has conducted reviews of the all state DOT agencies and their quality assurance (QA) programs as part of the FHWA's overall stewardship oversight function. The FHWA's Quality Assurance Stewardship Review – Summary Report for Fiscal Years 2003 through 2006 summarizes the reviews that have been conducted. Four stewardship reviews were completed in FY 2003, including Maine, Missouri, Colorado, and Oklahoma. Four stewardship reviews were completed in FY 2004, including California, Georgia, North Carolina, and New York. Four stewardship reviews were completed in FY 2005, including Maryland, Oregon, Minnesota and Connecticut. Finally, four stewardship reviews were completed in FY 2006 including Virginia, Wisconsin, Nebraska and Nevada. The stewardship reviews included:

1. Interviews with State agency headquarters, Region/District and field office personnel and FHWA personnel,
2. Review of State agency implementation strategies including policy and procedure documents and office records where applicable,
3. Visits to construction projects to assess field practices as appropriate, and
4. Identification of best practices.

The report highlighted the positive findings and the opportunities for improvement. One of the areas where there were opportunities for improvement was related to the use of contractor test results. The stewardship review found that most states need to strengthen their validation systems. The following items were identified by the FHWA as some potential problem areas (FHWA, 2007):

1. Not using independent samples for state verification samples;
2. No statistical comparison of contractor and state data;
3. A low state to contractor test ratio;
4. Poor control over contractor supplied data;
5. Lack of a defined time for comparing test results;
6. Not increasing testing frequencies when test results don't compare;
7. States not controlling the sampling location and timing;
8. States allowing biased retesting provisions; and
9. Lack of security for samples.

The National Cooperative Highway Research Program (NCHRP) conducted a research study on the quality assurance practices of state and federal departments of transportation with regard to highway materials and construction in 2005. The results from this study are contained in NCHRP's synthesis 346 (Hughes, 2005) and are highlighted throughout the report herein. This NCHRP synthesis summarizes the methods and procedures, including information on quality control, acceptance, independent assurance, and training/certification.

Chapter 3 - Survey and Interview of KYTC Engineers

The research project included both qualitative data, extracted from surveys and interviews, as well as quantitative data, extracted from actual Kentucky project data. This chapter is dedicated to a discussion of surveys and interviews conducted with various QC/QA stakeholders in Kentucky. Future sections of this report deal with the results of a nationwide survey and project data analysis.

3.1 KYTC Surveys and Data Collection

A questionnaire for the KYTC Engineers was developed with the intention of learning from their experience with QC/QA. This questionnaire was developed based upon a number of interviews, and major concerns which were raised during these interviews. All interviewees were allowed to start with an open ended introductory set of comments without any suggestions or hints from the interviewer so that these introductory comments would be bias free. This questionnaire, which is presented in Appendix - A, consisted of five major categories related to QC/QA:

1. Background;
2. QC/QA Procedures;
3. Training;
4. QC/QA Subcontracting; and
5. Lessons Learned.

A collection of interview responses which were provided during these interviews are presented in Appendix - B.

Upon the completion of KYTC interviews, the interview questions were later modified in order to make them applicable to Kentucky contractors and consultants. The questionnaires were administered to a select group of contractor or consultant in person. Similar to the KYTC interviews, all interviewees were allowed to start with an open ended introductory set of comments without any hints or suggestion from the interviewer so that these introductory comments would be bias free.

Interview responses varied in length from “No Answer-N/A” to multiple paragraphs. Where multiple persons were surveyed within a single firm, an effort was made to draw a composite picture of all comments.

Highway contractors and consultants from across Kentucky were invited and encouraged to participate in this research project. Additionally, contractors and consultants that perform work for KYTC and have headquarters outside the state of Kentucky were contacted to participate in this study. However, only in-state contractors and consultants agreed to contribute their time and efforts to this project. Their responses to the interviews and surveys are given in future sections of this report.

All interviewees were assigned fictitious names in this report in order to protect their identities. Due to the nature of heavy highway construction industry, the revelation of counties or cities where contractors are headquartered could serve as an identifier of that company and infringe on the anonymity that this report seeks to preserve. As such, the companies' geographic locations are only identified by their regional presence such as Central Kentucky, Eastern-Central Kentucky, or Western-Southern Kentucky.

3.2 KYTC Interviews

3.2.1 Summary of KYTC Comments about QC/QA Background

This section of the interview is focused on general background responses and comments. This provided an opportunity for generation of comments regarding the QC/QA system in Kentucky without the interviewer steering the interviewee in any particular direction.

Some concerns were raised regarding the potential shortage of trained personnel for QC/QA projects. This is especially true in light of the current retirement surge occurring at the Cabinet. Another concern was raised regarding the necessary data recording and tracking, which have been missing on some projects. However, it is hoped that with the implementation of the Site Manager program this problem may be solved in the near future.

A general concern was raised with reference to bonus schedules that sometimes overshadow penalties. For example, a contractor can receive a very high bonus payment for a very smooth asphalt road, while the asphalt may receive a penalty for less than desirable density. However, the net payment may still exceed 100% pay because the smoothness bonus can overshadow the density penalty. One can think of a variety of different solutions to this problem. For example, the KYTC could make the bonus for smoothness contingent upon 100% satisfactory result from asphalt density.

3.2.2 Summary of KYTC Comments about QC/QA Procedures

The focus of this section was the current QC/QA practices. For example, one of the questions in this section asked the interviewees if they feel that QC/QA practices are applied uniformly across the state.

There were some concerns regarding the uniformity by which QC/QA specifications are interpreted and implemented across the state. There were also some concerns regarding the true randomness of the test locations, since the locations were sometimes already known in advance by the contractors. Additionally, there were some concerns regarding the true independence of the KYTC testing. Not all such tests are always conducted by the KYTC staff using KYTC equipment. Sometimes this is due to the equipment shortage in the field, such as a shortage of nuclear density gages.

Regarding the amount of QC/QA testing, there was concern that there may not be enough testing on smaller size jobs. For example, on HMA jobs a test lot is 4,000 tons, and on some typical resurfacing jobs sometimes the entire job is approximately 4,000 to 6,000 tons. With these small size jobs there is only 1 to 1.5 testing lots, which some feel may be inadequate.

Finally, there was almost a unified suggestion that the KYTC should move toward using more non-destructive and non-nuclear technologies capable of measure the quality and potential performance of the finished product in the field and in real time. The example of highway paint stripe testing in Kentucky was commonly mentioned as a successful example of such a specification (Table 3.1).

Table 3.1: Summary of KYTC Concerns about QC/QA Procedures

KYTC Concerns about QC/QA Procedures
In regards to frequency of testing, typical resurfacing jobs have approximately 4,000 to 6,000 tons per job; this will only provide 1 to 1.5 testing lots. There was concern that this may not be adequate.
There was some interest expressed to implement a more in situ, non-destructive, and real time, quality measurement on the finished product for construction.
Contractors tend to lean on bonus factors, and depend on them as part of the pay in the contract. Concern was expressed that pay/bonus factors may be too lenient.
Concern was raised that contractors may sometimes be aware of the location of where DOT testing may be done, and this can compromise random testing.
There is some concern that QC/QA practices are not being implemented uniformly across the state; policies tend to vary from district to district.
Some expressed a concern about the shortage of KYTC inspectors on construction sites.

3.2.3 Summary of KYTC Comments about QC/QA Training

This section of the questionnaire focused on training programs, both for the KYTC personnel as well as the contractors and consultants. Generally speaking, most felt that the state was doing an adequate job in providing the right type of training for all parties concerned. There was a concern raised that there was inadequate training in the area of nuclear density gages (Table 3.2).

Table 3.2: Summary of KYTC Concerns about QC/QA Training

KYTC Concerns about QC/QA Training
The impression was that there was an adequate amount of training being provided to all parties concerned.
There was an interest in more training for the nuclear density gages.
There was some concern that there may be a shortage of trained QC/QA Quality Managers on individual projects.

3.2.4 Summary of KYTC Comments about QC/QA Subcontracting

QC/QA Subcontracts was another aspect of the Cabinet's QC/QA program examined during the interviews. This section was added to the questionnaire due the fact that some contractors subcontract their QC duties; likewise, the KYTC contracts some of its QA duties in some instances. Regarding QC/QA subcontracting, there seemed to be a general positive impression about the subcontracting companies. There were some concerns expressed that there may be a possible conflict of interest if the subcontractor does business with both the contractor and the KYTC. However, the impression was that the Cabinet is satisfied with their performance, and the regional control zones have helped reducing the potential for conflicts of interest cases (Table 3.3).

Table 3.3: Summary of KYTC Concerns about QC/QA Subcontracting

KYTC Concerns about Subcontracting
There were some concerns expressed that there may be a possible conflict of interest if the subcontractor does business with both the contractor and the KYTC. However, the impression was that the KYTC is satisfied with their performance, and the regional control zones have helped reducing the potential for conflicts of interest cases.
There was an impression that QC/QA subcontracting is growing especially among smaller contractors.
The comments reflected that, generally, the Cabinet has been satisfied with testing subcontractors and their performance.

3.2.5 Summary of KYTC Comments about QC/QA Lessons Learned

Lessons learned and future recommendations for the Cabinet's QC/QA program were also solicited. Lessons learned included concerns about not having adequate KYTC personnel on each project site. All interviews pointed out that the quality of finished product seems to be better in Kentucky as a result of the QC/QA specifications. Although it is difficult to de-couple the effects of QC/QA implementation from other changes in the highway construction in recent years, such as the implementation of Superpave specifications as related to asphalt construction. Finally, the suggestion was made to monitor the pay factors for all construction in Kentucky, and modify them as needed to correlate better with the value of good construction.

Chapter 4 - Survey and Interview of Kentucky Contractors

In order to examine the effectiveness of QC/QA from the contractors' perspective, a series of interviews with a select group of Kentucky contractors were conducted. It is important to note that every effort was made to assure clarity in communicating each of the interview questions, but answers supplied by interviewees reflect their subjective interpretation. As such, responses to questions are varied, yet each provides valuable insight into the effectiveness of the Kentucky QC/QA program. As mentioned in previous sections, companies offering responses for this research will be referenced only as a letter, e.g. A, B, and C, based upon their geographic region. Contractor and consultant locations will be given only by region of Kentucky, with no specific geographic identifiers. The region associated with each participant represents the location of their headquarters and not the full area in which they provide services. Contractors G and H are sister companies and offered one spokesperson to provide a single input on behalf of both companies.

Table 4.1: Participant Contractor Regions

Participant	Region of Kentucky Headquarters
Contractor-A	Eastern-Central
Contractor-B	Western-Southern
Contractor-C	Eastern-Central
Contractor-D	Central
Contractor-E	Central
Contractor-F	Central
Contractor-G	Central
Contractor-H	Western-Southern
Consultant-I	Central

Although multiple consulting engineering firms were invited to participate, only one (Consultant-I) agreed to participate in the interview and survey process. Consultant-I has the capacity to perform Quality Control work on behalf of the general contractor and also performs Quality Assurance work on behalf of KYTC in accordance with the KYTC imposed regional restrictions.

4.1 Background Interview Questions

4.1.1 Summary of Contractor Comments about QC/QA Background

Five out of eight contractors responded that they had a positive opinion toward the intent of the QC/QA program in Kentucky. Two contractors were neutral, offering no introductory comments, while only one contractor held a negative sentiment about the QC/QA program.

Owen Isaac of Contractor-F felt that one of the major consequences of the QC/QA program in Kentucky has been a reduction in the KYTC project staff, and he was concerned about the overall reduction in KYTC workforce. To this end, Mr. Isaac feared long term negative consequences.

Most contractors commented that the Kentucky QC/QA program has some areas that are better developed, such as asphalt, and some areas that are still in various stages of development, such as: concrete, aggregate, embankment. This set of contractors shared the general sentiment that the Kentucky Transportation Cabinet had been slow to implement the QC/QA program and that full implementation was necessary for success. Aaron McKenzie of Contractor-D, holding a favorable opinion of the program, noted that the program has forced contractors statewide to be more in control of their construction processes.

Representatives of Consultant-I used their response to offer a brief history of the Kentucky QC/QA program from their perspective, and proposed some suggestions for improvement. These consultants believed that the KYTC and Kentucky FHWA are often reluctant to trust the data submitted by the contractor or the consultant. Jimmy Lando suggested that perhaps the KYTC could increase the size of its project staff in order to be able to do more inspection; therefore, all project payments would be based upon the KYTC testing data.

4.1.2 Project Characteristics of Contractor Interviews

Fifty percent of the contractors interviewed did not specify individual projects, rather they spoke in broad form about their experience with the QC/QA program. The projects identified by the remaining contractors were 89% rural, non-interstate highways, and Contractor-B was the only participant to have employed QC/QA functions on an interstate highway project. All but one of the specific projects identified were viewed successfully by the respective contractor performing the work.

Consultant-I personnel also chose not to identify individual projects. Instead, this firm chose to address the remaining questions using their experience with the QC/QA program as a whole.

4.1.3 QC/QA Specifications Addressed during Contractor Interviews

While half of the respondents did not identify individual specifications, all eight contractors had used and were familiar with Hot Mix Asphalt (HMA, asphalt) specifications. Additionally, 75% of the participants had been involved with QC/QA projects that employed concrete specifications including Contractors-G and H. A majority of those interviewed had used embankment specifications while only three of eight had experience with QC/QA specifications for aggregate.

Contractor-D owns an in-house certified testing facility, and it does all QC/QA work with the exception of embankment. It also offers testing services to other contractors.

Consultant-I have personnel who are familiar with concrete, asphalt, aggregate, and embankment QC/QA specifications and has done work in all of these areas.

4.1.4 Adequacy of KYTC Personnel

The majority of responses to this question focused on the shortage of KYTC staff. Contractors-D and E were concerned about the ever increasing work load for the KYTC staff while the Cabinet staff has been shrinking. Ryan Bell of Contractor-E stated that in n 2007 the KYTC Central Office Materials Division was responsible for approving approximately 800 asphalt mix designs. In his opinion, this was an unreasonably large work load for the limited number of staff in that division. He further suggested that a temporary solution might be reducing the number of asphalt mix varieties in Kentucky.

Contractors-A and C agreed that it was difficult to gauge the adequacy of KYTC personnel across the state, some districts are better staffed than others. A more serious problem in their opinion was the lack of uniformity in interpretation of QC/QA specifications across the state.

Mack Davis of Consultant-I stated that KYTC personnel are more stretched now than at any other time during his tenure in the highway construction industry. He recognized that there are still a number of very effective district offices in the state, but he made the point that highway industry has been very successful with attracting highly experienced KYTC staff away from the Cabinet in recent years.

4.1.5 Adequacy of KYTC Inspection Personnel

Fifty percent of respondents were positive about the quality of the KYTC inspection workforce; however, they would prefer to see more KYTC inspectors on the job site. Aaron McKenzie of Contractor-D and Ryan Bell of Contractor-E noted that the level of KYTC inspection strength varies depending on the district.

As a Quality Manager, Gabe Clark of Contractors-G and H noted that while he is very comfortable with QC inspection functions, his field and laboratory personnel often are not. Mr. Bell suggesting that the chain of custody of laboratory and field specimens should be better defined and enforced.

Ethan Strait of Contractor-A stated that testing procedures for asphalt properties vary depending on the KYTC district practices. Some districts, he said, perform QA properties testing at the KYTC District Materials office, while others perform their testing at the contractor's laboratory. Mr. Strait asserted that KYTC District Materials offices should be responsible for all verification testing.

Representatives of Consultant-I expressed that their experience with some general contracting firms revealed that such firms often are not very familiar with the QC/QA process. Jimmy Lando stated that in such cases the general contracting firm should hire a qualified Quality Manger to oversee its QC/QA process. Mack Davis of the firm suggested that the KYTC training programs be limited, and it might be a good idea for the KYTC to accept other training venues such as National Institute for Certification in Engineering Technologies (NICET) or International Building Code (IBC).

4.1.6 Enforcement of Verification Testing

Seven of the eight contractors interviewed believed that enforcement is generally fair and justified. Three of those contractors, however, believed that verification testing varied depending on the circumstances at the jobsite. Sometimes verification and enforcement was a function of the KYTC division (Materials of Construction) that took a more active role on the project.

In contrast to the majority of the contractors interviewed, Consultant-I stated that enforcement was not fair and sometimes not fully justified. Mr. Davis noted that contractor and KYTC nuclear gages are often not jointly calibrated; an issue that can lead to discrepancies in field density readings. He asserted that to achieve a fairer system, contractors and the Kentucky Transportation Cabinet would need to calibrate their equipment more frequently. Mr. Davis further stated that, in his opinion, the KYTC's soil inspection program was weak.

4.1.7 Verification and Potential Conflicts of Interest between Testing Agencies and KYTC

While comments varied among respondents, fifty percent believed that conflicts of interest could be an issue. Avery Jones of Contractor-C, a firm seeing no conflicts of interest issues, expressed the opinion that third-party testing agencies are not needed for the purposes of QC/QA.

According to Consultant-I, the issues that exist between testing agencies and the Transportation Cabinet could be improved by increasing the involvement of the KYTC Central Office Materials Division. Mack Davis suggested that Materials Division Central Office has the most expertise in this area, and they need the staff to have a more active role.

4.2 QC/QA Procedures

4.2.1 Clarity of Testing Protocols

All of the contractors interviewed believed that the testing protocols for HMA were clearer than other construction items. Only three contractors, however, felt that testing protocols were clear for all of the materials within the KYTC QC/QA program. The remaining five contractors took issue with the clarity of QC/QA specifications that govern materials other than HMA, especially those addressing concrete and aggregate. Logan Carter of Contractor-B again addressed the lack of uniformity in interpretation and enforcement of QC/QA specifications across the state. Consultant-I agreed with those contractors who thought KYTC protocols were generally clear and concise, but noted that additional detail outlining what tests were to be performed and which party was responsible for a given test would be helpful.

Contractor-A, also a concrete producer, felt like the Transportation Cabinet could do a better job with communicating the start and status of a project to all involved parties. Mr. Strait argued that the producer typically will not be informed when he or she must start testing concrete and perform additional tests until after the project has started. He stated that better coordination was imperative and, in his opinion, KYTC as the owner of the finished project has the responsibility to better communicate with all parties involved.

4.2.2 Scope of QC/QA Specifications

Seven of eight contractors believe that, in general, the right items are being tested to measure quality. Five of the contractors interviewed, however, felt that improvements could be made to the system. Some of the recommendations offered included changes to current tests, others were requests for better defined testing. The following recommendations have been identified as potential areas of future improvement:

- Further clarify the testing on liquid asphalt binder
- Develop a non-destructive way to test asphalt surface material properties
- Implement a strength test for HMA pavement
- Implement Proctor testing for Dense Graded Aggregate (DGA)

The participating consultant firm agreed with the majority of contractors that typically the right things are being tested to assure a quality product.

4.2.3 Uniform Application of QC/QA practices

Five contracting firms believed that QC/QA practices are not applied uniformly across the state. Contractors-C, G, and H, identified the process of asphalt coring as a major variant with regard to uniformity of practice. All of these contractors noted that KYTC practices could be inconsistent with respect to obtaining cores, and the chain of custody of specimens. Mack Davis and Jimmy Lando of Consultant-I agreed with the comments made by Contractors-C, G, and H.

The contracting firms were also asked if there were any significant deviation of the QC/QA specifications that regularly occurred on projects, but none of the contractors and consultants interviewed identified a specific area. However, a majority agreed that variations in interpretation and enforcement of QC/QA specifications do exist in Kentucky.

4.2.4 Improving the Accuracy of QC/QA Measurements

All of the contractors interviewed had general recommendations regarding the improvement of the QC/QA system. These recommendations are summarized below.

- Offer special QC/QA training on a more frequent basis.
- Provide more oversight in testing of liquid asphalt binder.
- Use statistics to track data (F-test, t-test, etc.).
- Apply uniform enforcement across the state.
- Apply better calibration procedures to testing device, particularly nuclear density gauges.
- All pay related materials sampling and testing should be handled by the KYTC Materials personnel.
- Develop an alternative to the nuclear gages.

4.2.4.1 New QC/QA Technologies

State DOTs are faced with the challenge of phasing out the old technologies and replacing them with the new, without any work interruption. Another challenge is the ability to deal with new problems that a new technology may be introducing. For example, one of the latest methods in construction and materials testing is Cross-Hole Sonic Logging (CSL). This is a relatively new procedure for testing concrete properties, particularly strength. The testing process is also designed to help identify voids in concrete bridge pier castings. However, according to Ian Green of Contractor-F, the usage of CSL on one of their projects was the cause for significant delay and increased project cost. The source of this problem seemed to be the electronic noise that can occur occasionally in this type of a sonic wave data, and it may cause a false warning on the project.

4.2.5 QC/QA Testing Frequency

Seventy-five percent of the contractors interviewed made the statement that the Kentucky QC/QA testing was done at the right frequency. Contractors-A and D, however, felt that the testing frequency for concrete was excessive. Each made the point that for small quantities, concrete testing frequency must be adjusted. Ethan Strait (Contractor-A) mentioned that, even if the construction item is incidental to the project, the contractor is still required to make a set of concrete cylinders for compressive strength test.

Consultant-I thought that the frequencies designed for Quality Control functions were adequate. However, Quality Assurance frequency may not be high enough to adequately represent the lot.

4.2.6 Fairness of pay adjustment factors

All of the participating contractors felt that the current pay factors, incentives and disincentives, were fair. Several contractors made note of a recent change in the HMA density specifications. The contractors liked the change which relaxed the HMA density pay scales. Consultant-I agreed that all of the pay adjustment factors for contractors were fair.

4.3 QC/QA Training

4.3.1 QC/QA Training of KYTC Staff

Five of the eight contractors believed that the KYTC staff is adequately trained to perform the Quality Assurance functions of the program. They also emphasized that there is a need for experienced field inspectors to do a good job with the QA functions. Sam Blacker and Jimmy Lando of Consultant-I supported the addition of more experienced KYTC inspectors. None of the participants recommended additional training for KYTC staff.

4.3.2 QC/QA Training of Contractor Staff

Fifty percent of the participating contractors believed that their staff is adequately trained to perform the Quality Control functions of the program effectively. Contractor-F subcontracts 100% of the QC function on his jobsites and, as such, has no Quality Control personnel on staff to answer this question. Contractor-B was the only participant to recommend or suggest additional training for his QC staff. Logan Carter stated that his company was trying to move toward a “visual training.” Mr. Carter hopes that this will produce inspectors that are comfortable with watching a material being placed, knowing how it will behave, and if the placement is in accordance with the specifications.

Consultant-I was confident that their staff was adequately trained to perform Quality Control and Quality Assurance functions. Jimmy Lando asserted that if NICET or IBC training was recognized by KYTC, their staff would participate.

4.3.3 Quality Manager Workloads

There are two variables that must be considered when evaluating the workloads of quality managers. The first variable is that every contractor has a different definition of “Quality Manager.” The second consideration is that the number of projects a manager would oversee is often a function of project size. Therefore, the participating contractors reported that Quality Managers would oversee an average of four projects at one time. Contractor-B reported overseeing as many as eight projects at a time, while Contractor-C claimed to have one Quality Manager per project. The participating consultant stated that their firm limits Quality Managers to two projects at a time so as to maintain effectiveness on each jobsite.

4.4 QC/QA Subcontracting Responses

4.4.1 Extent of your QC/QA subcontracting

Seven of the eight contractors do their entire QC testing in-house and do not engage in subcontracting these functions. Contractor-F was the only company that subcontracts 100% of its Quality Control functions. This contractor mentioned that at the beginning of the QC/QA program implementation in Kentucky the company considered building in-house capacity for their QC testing. However, their economic analysis favored subcontracting all of their QC functions.

Consultant-I most frequently performs work as a subcontractor for QC/QA contractors. This consultant indicated that their in-house capacity allows them to do all of their contract work in-house without a need for subcontracting.

4.4.2 QC/QA Subcontractor Performance

All of the contracting firms using Quality Control subcontractors reported that their testing subcontractors have met or exceeded expectations. Owen Isaac of Contractor-F and

Logan Carter of Contractor-B stated that they have been very pleased with the performance of their Quality Control subcontractors. Contractors-C and E believed that their subcontractors have performed well.

4.4.3 Subcontractor Involvement and Conflict of Interest

Seventy-five percent of the participating contractors believed that the KYTC regional work restrictions have worked well in minimizing and eliminating the potential for conflicts of interest cases. Mot contractors believed that a perception of conflicts of interest should be examined against the actual evidence before raising a red flag.

A potential drawback with involving subcontractors, which was expressed by some contractors, is the potential confusion between KYTC and the subcontractor over the power to reject poor construction. Consultant-I did not see any problem with privatizing the KYTC QA functions, and believed that it could make the system more efficient.

4.5 Kentucky Contractor QC/QA Lessons Learned

Mr. Isaac of Contractor-F again asserted satisfaction with his subcontractors and the decision made by his company to outsource all of the Quality Control functions associated with their projects. Below are a list of comments and lessons learned provided by the respondents.

- Maintain good communications with all parties involved with a project.
- The program has encouraged better quality work.
- The program has led to a more educated contracting staff.
- Contractor partnering with KYTC is effective.
- To be successful, every firm needs a dedicated Quality Control Manager.
- Assigning laptop computers to foremen for data entry has helped to streamline the data recording and tracking functions.

Consultant-I suggested that testing subcontractors need to review the wording of their contracts very carefully. Testing contracts may be defined in terms of dollars per test, or dollars per day, or a lump sum dollar figure for the entire job. Additionally, Consultant-I suggested that the QC/QA program would benefit from having a senior KYTC staff serve as the champion of the program.

4.5.1 Impact of QC/QA Specifications on Project Quality

Seventy-five percent of contractors' personnel were involved in highway construction projects prior to the implementation of the Kentucky QC/QA program. It is the belief of all but one of those contractors that the program is contributing to better quality construction. In addition, the two respondents who were not involved in highway construction before KY QC/QA was implemented, as well as Consultant-I, all shared the view that the Kentucky QC/QA program is producing good quality finished product.

4.5.2 Suggested Changes to QC/QA Specifications

Five of the eight participating contractors noted that they would like to see changes made in the use of QC/QA on their projects. Most of the recommendations made by the respondents were changes or adjustments in the specification language. Contractor-E made the suggestion that KYTC should create a Quality Assurance division as opposed to subcontracting the task. The recommended changes in specification language are presented below:

- Tighten all of the aggregate gradation bands to help minimize large variations in construction materials.
- Better define the sample collection responsibilities, and the chain of custody of laboratory and field specimens.
- Add more language to the QC/QA specifications in order to reduce the potential for variability in interpretation.
- Better define the role of various parties and their respective range of responsibilities in the larger QC/QA regime.

Chapter 5 - Quantitative Project Data and Statistical Analysis

5.1 Data Background

The data presented in this chapter was provided by the KYTC Division of Materials, Central Office and includes samples of QC/QA asphalt and concrete projects.

5.2 Statistical Data Analysis of QC/QA Hot Mix Asphalt Data

Hot mix asphalt (HMA) projects were the first to be implemented under a QC/QA system. Since 1997, Kentucky has been using a QC/QA program for HMA projects.

5.2.1 HMA Data Collection Method

Kentucky's QC/QA program for HMA is performed on a lot basis, where a lot is comprised of 4000 tons of HMA. Each lot is then sub-divided into four sublots (1 sublot = 1000 ton of HMA). The contractor is responsible for testing all four sublots within a lot for quality control. However, the KYTC conducts verification testing only on one randomly selected sublot within a lot. There are many characteristics of HMA that are closely monitored and checked for quality; chief among them are:

1. Unit Weight (lb/ft^3);
2. Percent Voids; and
3. Percent VMA (Voids in Mineral Aggregate)

A sample of Kentucky QC/QA project data were examined for this study. The original data set submitted by the Division of Materials included a total of 171 lot-files. Of those 171 lots, only 88 lots contained KYTC verification data. As such, the remaining 83 files which did not include KYTC verification data were not included in this study. The largest project in the study contained 18 lots, while the smallest project contained 3 lots. The statistical analysis presented here was based on data from 7 Kentucky counties, including: Carter, Fayette, Fayette-Clark, Gallatin, Hardin, Madison-Rockcastle, and Scott. The statistical data analysis focused on the following questions:

1. Is there a statistically significant difference between the testing that is done by the Contractor versus the side-by-side KYTC verification testing?
   Notation: "1 Contractor Vs. 1 KYTC".
2. Is there a statistically significant difference between the three sublots that are not verified by the KYTC versus the one sublot that is verified by the KYTC? **Notation:** "3 Contractor Vs. 1 KYTC".
3. Is there a statistically significant difference between all four sublots reported by the contractor versus the KYTC verification testing on that lot?
   Notation in: "4 Contractor Vs. 1 KYTC".

5.2.2 Statistical Data Analysis

The most commonly used guide for QC/QA data analysis is a report which was prepared by AASHTO: AASHTO Procedure for Comparison of Quality Control and Acceptance Tests

(AASHTO, 1996). According to this report, to compare two normally distributed populations, one may compare their means and their variances. Two different statistical tests are used for each of these properties. The F-test provides a method for comparing the variances, and differences in means are assessed by the t-test. Both tests (F-test and t-test) are conducted at a pre-selected level of significance, commonly referred to as α. The value of α is typically selected as either 0.05 or 0.01. The data analysis in this report is based upon α = 0.01, which is recommended by AASHTO. It must be noted here that this is a very stringent requirement, as compared to most statistical analyses which are routinely conducted at α = 0.05.

In the AASHTO procedure, the F-test to verify equality of variances is performed first, before the t-test for means. Depending on the outcome of the F-test, that is, variances being equal or not, there are two separate equations for the t-test that must be followed. If the sample variances are shown to be not different, then the t-test is conducted. This t-test is based upon the two samples using a pooled estimate for the variances and the pooled degrees of freedom. If the sample variances are shown to be different, then the t-test is conducted using the individual sample variances, the individual sample sizes, and the effective degrees of freedom.

5.2.3 Summary of Statistical Analysis Based Upon AASHTO Procedure

Data gathered from 88 HMA lots were analyzed according to AASHTO procedure and summarized below.

A. Problem Statement #1: Is there a statistically significant difference between the testing that is done by the Contractor versus the side-by-side KYTC verification testing? Notation: "1 Contractor Vs. 1 KYTC".

Since Kentucky uses split sample for side-by-side verification testing, paired t-test was used to compare the means. The following statistical hypothesis can be made for the paired t-test:

$H_0 : \overline{X_c} = \overline{X_a}$; (There is no significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

$H_1 : \overline{X_c} \neq \overline{X_a}$; (There is a significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

Fig 5.1: Schematic Diagram Representing Problem Statement #1

Table 5.1a: Summary of Project Means (1 Contractor vs. 1 KYTC)

Projects	Source	N	Properties		
			Unit Weight (lb/ft^3)	Percent Voids	Percent VMA
			Mean	Mean	Mean
Carter	Contractor	18	151.63	3.02	13.27
	KYTC	18	151.30	3.24	13.48
Fayette	Contractor	3	153.80	4.16	11.66
	KYTC	3	153.60	4.23	11.76
Fayette-Clark	Contractor	5	154.64	3.68	11.08
	KYTC	5	154.42	3.88	11.30
Gallatin	Contractor	14	149.22	3.95	15.41
	KYTC	14	149.32	3.92	15.27
Hardin	Contractor	6	149.65	4.38	14.55
	KYTC	6	149.36	4.46	14.66
Madison-Rockcastle	Contractor	7	153.45	4.11	12.01
	KYTC	7	153.18	4.02	12.18
Scott P1	Contractor	6	150.06	4.81	13.91
	KYTC	6	150.08	4.60	14.05
Scott P2	Contractor	6	150.85	2.91	13.90
	KYTC	6	150.18	3.25	14.23

Table 5.1b: Paired t-test Summary (1 Contractor vs. 1 KYTC)

Projects	Properties					
	Unit Weight (lb/ft^3)		Percent Voids		Percent VMA	
	t-statistic	Sig.Level (2-tailed)	t-statistic	Sig.Level (2-tailed)	t-statistic	Sig.Level (2-tailed)
Carter	3.63	0.002	-3.986	0.001	-2.681	0.016
Fayette	3.464	0.074	-0.459	0.691	-0.866	0.478
Fayette-Clark	5.88	0.004	-3.651	0.022	-2.994	0.04
Gallatin	-3.373	0.005	0.888	0.391	2.11	0.055
Hardin	1.135	0.308	-0.442	0.677	-0.848	0.435
Madison-Rockcastle	1.61	0.159	0.812	0.448	-1.686	0.143
Scott P1	-0.093	0.93	2.071	0.093	-1.397	0.221
Scott P2	5.822	0.002	-6.742	0.001	-3.78	0.013

Table 5.1b presents the results of comparing contractor's QC data with the side-by-side KYTC verification data on a project-by-project basis. The results are based upon paired t-test for equality of means. The analysis showed that there was not any significant difference between the contractor reported data and the KYTC verification data, except where the data are highlighted. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

B. Problem Statement #2: Is there a statistically significant difference between the three sublots that are not verified by the KYTC versus the one sublot that is verified by the KYTC? Notation: "3 Contractor Vs. 1 KYTC".

To address this question, the following hypotheses were made, one for variances and one for means. The following hypotheses were made to compare variances:

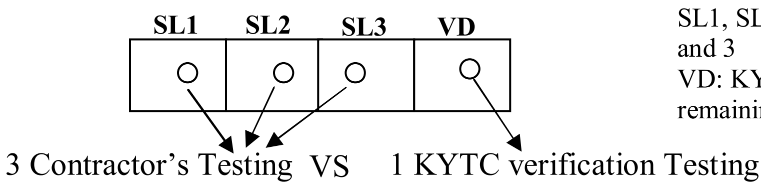
$H_0 : s_c^{\,2} = s_a^{\,2}$; (There is no significant difference between variances in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

$H_1 : s_c^{\,2} \neq s_a^{\,2}$; (There is a significant difference between variances in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

The following hypotheses were made for the independent sample t-test:

$H_0 : \overline{X}_c = \overline{X}_a$; (There is no significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

$H_1 : \overline{X}_c \neq \overline{X}_a$; (There is a significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)



Notation:
SL1, SL2, SL3: Contractor's QC data from sublot 1, 2 and 3
VD: KYTC's randomly verification data from remaining sublot

Fig 5.2: Schematic Diagram Representing Problem Statement #2

Table 5.2a: Summary of Project Means (3 Contractor vs. 1 KYTC)

Projects	Source	N	Properties		
			Unit Weight (lb/ft^3)	Percent Voids	Percent VMA
			Mean	Mean	Mean
Carter	Contractor	54	150.97	3.51	13.67
	KYTC	18	151.63	3.02	13.27
Fayette	Contractor	9	154.25	3.93	12.74
	KYTC	3	153.80	4.16	11.66
Fayette-Clark	Contractor	15	154.54	3.84	11.24
	KYTC	5	154.64	3.68	11.08
Gallatin	Contractor	42	149.54	3.81	15.
	KYTC	14	149.22	3.95	15.41
Hardin	Contractor	18	149.93	3.85	14.49
	KYTC	6	149.65	4.38	14.55
Madison-Rockcastle	Contractor	21	153.50	3.86	11.99
	KYTC	7	153.45	4.11	12.01
Scott P1	Contractor	18	151.13	4.03	13.44
	KYTC	6	150.06	4.81	13.91
Scott P2	Contractor	18	149.12	4.05	14.88
	KYTC	6	150.85	2.91	13.90

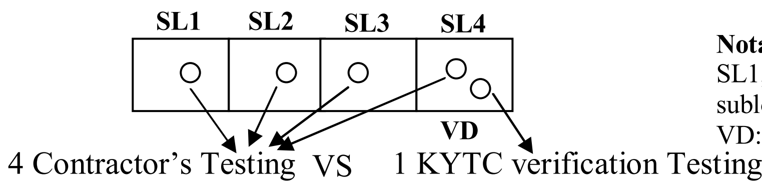
Table 5.2b: F-test and T-test Summary (3 Contractor vs. 1 KYTC)

Projects	Properties											
	Unit Weight (lb/ft^3)				Percent Voids				Percent VMA			
	F-test		T-test		F-test		T-test		F-test		T-test	
	F	F_{crit}	Statistic	Sig.	F	F_{crit}	Statistic	Sig.	F	F_{crit}	Statistic	Sig.
Carter	3.61	2.39	2.389	0.027	4.22	2.39	2.613	0.017	2.48	2.39	2.898	0.008
Fayette	1.44	11.0	0.742	0.475	1.34	11.0	0.589	0.569	34	11.0	0.87	0.406
Fayette-Clark	2.9	5.8	0.28	0.783	2.63	5.8	0.66	0.517	1.83	5.8	0.829	0.418
Gallatin	1.98	4.23	0.597	0.553	2.46	4.23	0.417	0.679	1.77	4.23	0.861	0.393
Hardin	8.15	5.37	0.272	0.795	8.2	5.37	0.73	0.496	7.67	5.37	0.093	0.93
Madison-Rockcastle	1.22	4.47	0.087	0.931	1.59	4.47	0.727	0.474	1.31	4.47	0.065	0.949
ScottP1	1.61	5.37	2.814	0.01	1.69	5.37	2.879	0.009	1.43	5.37	2.237	0.036
Scott P2	2.29	5.37	2.297	0.032	18.58	5.37	3.536	0.002	2.2	5.37	2.248	0.035

According to Table 5.2b, these is no significant difference between any of the comparisons shown except as highlighted. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

C. Problem Statement #3: Is there a statistically significant difference between all four sublots reported by the contractor versus the KYTC verification testing on that lot? Notation in: "4 Contractor Vs. 1 KYTC".

The hypotheses in this case are almost identical to the problem #1, which was discussed earlier. A conceptual schematic of these comparisons is given in Figure 5.3.



Notation:
SL1, SL2, SL3, SL4: Contractor's QC data from sublot 1, 2 , 3 & 4
VD: KYTC's randomly verification data from

Fig 5.3: Schematic Diagram Representing Problem Statement #3

Table 5.3a: Summary of Project Means (4 Contractor vs. 1 KYTC)

Projects	Source	N	Unit Weight (lb/ft^3)	Percent Voids	Percent VMA
			Mean	Mean	Mean
Carter	Contractor	72	151.05	3.45	13.62
	KYTC	18	151.63	3.02	13.27
Fayette	Contractor	12	154.09	4.00	12.50
	KYTC	3	153.80	4.16	11.66
Fayette-Clark	Contractor	20	154.51	3.85	11.26
	KYTC	5	154.64	3.68	11.08
Gallatin	Contractor	56	149.48	3.84	15.18
	KYTC	14	149.22	3.95	15.41
Hardin	Contractor	24	149.79	4.00	14.53
	KYTC	6	149.65	4.38	14.55
Madison-Rockcastle	Contractor	28	153.42	3.90	12.04
	KYTC	7	153.45	4.11	12.01
Scott P1	Contractor	24	150.87	4.17	13.59
	KYTC	6	150.06	4.81	13.91
Scott P2	Contractor	24	149.39	3.85	14.72
	KYTC	6	150.85	2.91	13.90

Table 5.3b: F-test and T-test Summary (4 Contractor vs. 1 KYTC)

Projects	Properties											
	Unit Weight (lb/ft^3)				Percent Voids				Percent VMA			
	F-test		T-test		F-test		T-test		F-test		T-test	
	F	F_{crit}	Statistics	Sig.	F	F_{crit}	Statistics	Sig.	F	F_{crit}	Statistics	Sig.
Carter	2.25	3.48	2.638	0.01	2.77	3.48	3.007	0.003	1.56	3.48	2.894	0.005
Fayette	1.31	8.91	0.478	0.641	1.27	8.91	0.407	0.69	25.4	8.91	0.871	0.40
Fayette-Clark	2.38	20.2	0.405	0.689	2.23	20.2	0.769	0.45	1.48	20.2	1.004	0.326
Gallatin	1.65	4.12	0.489	0.627	1.85	4.12	0.322	0.748	1.45	4.12	0.749	0.457
Hardin	3.07	12.8	0.188	0.852	3.06	12.8	0.708	0.485	3.12	12.8	0.029	0.977
Madison-Rockcastle	1.18	9.36	0.076	0.94	1.41	9.36	0.655	0.517	1.31	9.36	0.10	0.921
Scott1	1.12	12.8	1.929	0.064	1.82	12.8	2.33	0.027	1.04	12.8	1.353	0.187
Scott 2	2.16	12.8	2.03	0.052	15.5	12.8	1.944	0.062	2.08	12.8	1.958	0.06

The F-test results indicated that there was no reason to believe that the four subblots tested by the contractor had a different variability when compared to the KYTC verified sublots. The t-test results also showed the same trend. That is, there was no statistically significant difference between the means of QC data as reported by the contractor versus those verified by the KYTC. The only exception was the project in the Carter County, where the t-test values showed that averages of sublot data showed significant differences for percent voids and percent VMA. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

5.3 Statistical Analysis of QC/QA Portland Cement Concrete Data

Similar to hot mix asphalt, Kentucky Transportation Cabinet has adopted QC/QA specifications for portland cement concrete. The initial concrete QC/QA specifications covered both structures and pavements, and it employed a percent within limits (PWL) approach. Later the PWL was limited to only concrete pavements. Unfortunately for the purposes of this study, Kentucky PCCP project data were limited, and the KMIMS data logs were mostly incomplete. Therefore, all concrete data analyses presented herein are based upon structural concrete.

5.3.1 PCC Data Collection Method

Each concrete pavement lot is defined as 4000 square yards of pavement, and each lot contains four sublots of each 1000 square yard. The contractor is responsible for day-to-day testing and quality control. However, all data must be transparent, and one out of every four sublots is randomly selected by the KYTC Engineer for verification testing. There are many characteristics of concrete that are closely monitored and checked for quality; chief among them are:

1. Slump,

2. Air Content, and
3. Compressive Strength.

The PCC data presented in this report were extracted from the KYTC-KMIMS. The data pool included six projects which involved the QC/QA specifications. The KYTC-KMIMS database employs a data coding system by which the source data can be traced. For example, data are identified by the lot number, and sublot number. The code “A” denotes acceptance, and “V” denotes verification. Therefore, a sample from Lot 1, Sublot 3, used for verification would be designated as 1-3-V. Unfortunately, of the six projects which involved the QC/QA specifications, only one contained a rich database which included verification data. This project was designated as 10707 by KYTC. Another project which was designated as 61009 contained only acceptance and verification data, but no further information was provided about lots or sublots. Therefore, only statistical analysis based on all verification and acceptance data was conducted for project 61009.

The statistical analysis performed and reported in this report focused on the following three questions:

1. Is there a statistically significant difference between the testing that is done by the Contractor versus the side-by-side KYTC verification testing?
   Notation: “1 Contractor Vs. 1 KYTC”.
2. Is there a statistically significant difference between the three sublots that are not verified by the KYTC versus the one sublot that is verified by the KYTC? **Notation:** “3 Contractor Vs. 1 KYTC”.
3. Is there a statistically significant difference between all four sublots reported by the contractor versus the KYTC verification testing on that lot?
   Notation in: “4 Contractor Vs. 1 KYTC”.

5.3.2 Statistical Data Analysis

To address the above mentioned questions, AASHTO Procedure for Comparison of Quality Control and Acceptance Tests was used as described in the following sections.

5.3.2.1. Concrete Project 10707

Project 10707 was a grade and drain project on US 119 in Pike county. The concrete cylinder data reported in KMIMS for this project contained test data for four Classes of concrete: A, AA, AAA, and D. However, data for Classes AA and AAA were not recorded properly, and for the most they were incomprehensible. Therefore, they were discarded from this analysis. Data from remaining two Classes of concrete (A and D) were analyzed by the procedure discussed earlier. Specifics of the analysis are presented in the following sections.

A. Problem Statement #1: Is there a statistically significant difference between the testing that is done by the Contractor versus the side-by-side KYTC verification testing? Notation: “1 Contractor Vs. 1 KYTC”.

To address this question, two separate sets of hypotheses were established; one for variances and one for means.

The following hypotheses were established for the F-test.

$H_0 : s_c^{\,2} = s_a^{\,2}$; (There is no significant difference between variances in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

$H_1 : s_c^{\,2} \neq s_a^{\,2}$; (There is a significant difference between variances in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

The following hypotheses were established for the t-test.

$H_0 : \overline{X_c} = \overline{X_a}$; (There is no significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

$H_1 : \overline{X_c} \neq \overline{X_a}$; (There is a significant difference between means in the testing that is done by the Contractor versus the side-by-side KYTC verification testing.)

The results of these hypotheses F-test and t-test for were summarized in Table 5.4.

Table 5.4a: Summary of Means for Project 10707 (1 Contractor vs. 1 KYTC)

Class of Concrete	Source	N	Properties		
			Air Content (%)	Slump (in)	Compressive Strength (psi)
			Mean	Mean	Mean
A	Contractor	50	5.75	2.79	4626.30
	KYTC	50	5.66	2.9	4751.20
D	Contractor	3	5.37	2.27	5196.22
	KYTC	3	4.80	2.21	6081.43

Table 5.4b: F-test and t-test Summary for Project 10707 (1 Contractor vs. 1 KYTC)

Class of Concrete	Properties											
	Air Content (%)				Slump (in)				Compressive Strength (psi)			
	F-test		t-test		F-test		t-test		F-test		t-test	
	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}
A	1.03	2.23	0.340	2.617	1.04	2.23	0.941	2.617	2.14	2.23	0.833	2.617
D	1.08	1.99	0.581	4.604	2.15	1.99	0.156	4.604	5.13	1.99	1.539	4.604

The overall statistical analysis revealed that for both classes of concrete (A and D) there was not a significant difference between the contractor QC data versus the KYTC verification data. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

B. Problem Statement #2: Is there a statistically significant difference between the three sublots that are not verified by the KYTC versus the one sublot that is verified by the KYTC? (Notation: "3 Contractor Vs. 1 KYTC").

To address these questions, a series of hypotheses were constructed in a manner similar to Problem Statement #1, except the comparisons targeted the "three versus one" sublots. The results of this analysis were summarized in Table 5.5.

Table 5.5a: Summary of Means for Project 10707 (3 Contractor vs. 1 KYTC)

Class of Concrete	Source	N	Properties		
			Air Content (%)	**Slump (in)**	**Compressive Strength (psi)**
			Mean	Mean	Mean
A	Contractor	150	5.68	2.80	4709.56
	KYTC	50	5.66	2.90	4751.20
D	Contractor	9	4.98	2.35	5634.07
	KYTC	3	4.80	2.21	6081.43

Table 5.5b: F-test and t-test Summary for Project 10707 (3 Contractor vs. 1 KYTC)

Class of Concrete	Properties											
	Air Content (%)				**Slump (in)**				**Compressive Strength (psi)**			
	F-test		t-test		F-test		t-test		F-test		t-test	
	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}
A	1.08	1.80	0.060	2.617	2.22	1.80	1.093	2.660	2.24	1.80	0.314	2.660
D	2.04	11.0	0.285	3.169	1.47	11.0	0.478	3.169	2.35	11.0	1.155	3.169

The analysis presented in Table 5.5b revealed that there was no significant difference between the three sublots that were not verified versus the one that was verified by the KYTC. The only exceptions were the highlighted areas. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

C. Problem Statement #3: Is there a statistically significant difference between all four sublots reported by the contractor versus the KYTC verification testing on that lot? (Notation: 4 Contractor vs. 1 KYTC)

To address these questions, a series of hypotheses were constructed in a manner similar to Problem Statements #1 and #2, except the comparisons targeted the "four versus one" sublots. The results of these analyses were summarized in Table 5.6b.

Table 5.6a: Summary of Means for Project 10707 (4 Contractor vs. 1 KYTC)

Class of Concrete	Source	N	Properties		
			Air Content (%)	Slump (in)	Compressive Strength (psi)
			Mean	Mean	Mean
A	Contractor	200	5.69	2.80	4688.74
	KYTC	50	5.66	2.90	4751.20
D	Contractor	12	5.08	2.33	5524.61
	KYTC	3	4.80	2.21	6081.43

Table 5.6b: F-test and t-test Summary for Project 10707 (4 Contractor vs. 1 KYTC)

Class of Concrete	Properties											
	Air Content (%)				Slump (in)				Compressive Strength (psi)			
	F-test		t-test		F-test		t-test		F-test		t-test	
	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}	F	F_{crit}	Statistic	t_{crit}
A	1.06	1.80	0.157	2.617	1.74	1.80	1.332	2.617	2.22	1.80	0.479	2.660
P	1.83	8.91	0.446	3.012	1.47	8.91	0.420	3.012	2.88	8.91	1.330	3.012

The analysis presented in Table 5.6b revealed that there was not a significant difference between the four sublots that were tested by the contractor versus the one that was verified by the KYTC. The only exception was the highlighted area. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

For Project 10707, statistical analyses revealed that, generally speaking, the contractor reported data and the KYTC verification data were similar. There were only a few isolated cases that did not follow this general trend.

5.3.2.2Concrete Project 61009

This project was located in Simpson County and it involved widening of I-65 to six lanes from 0.23 miles south of the Tennessee state line to the Bowling Green Road, which is located 0.9 mile south of the KY-100 interchange. The KMIMS databank was closely examined for data retrieval, and three Classes of concrete were identified for this project (Classes A, AA, and B). The data included both the contractor reported data as well as KYTC verification data. However, it was very unfortunate that the data for this project were not linked to specific lots and sublots. Therefore, a detailed statistical analysis, similar to the previous section, was impossible. Only a global comparison between the contractor reported data and the KYTC verification data was possible for this project. The summary of this global statistical analysis is given in Table 5.7b.

Table 5.7a: Summary of Means for Project 61009 (Contractor All vs. 1 KYTC)

Class of Concrete	Source	N	Properties		
			Air Content (%)	Slump (in)	Compressive Strength (psi)
			Mean	Mean	Mean
A	Contractor	236	5.11	2.00	5629.24
	KYTC	34	5.29	3.67	4772.28
AA	Contractor	73	5.92	3.72	5747.25
	KYTC	8	6.03	3.68	6039.71
B	Contractor	9	5.60	4.44	3301.22
	KYTC	4	6.00	4.44	2673.90

Table 5.7b: F-test and T-test Summary for Project 61009 (Contractor All vs. 1 KYTC)

Class of Concrete	Properties											
	Air Content (%)				Slump (in)				Compressive Strength (psi)			
	F-test		T-test		F-test		T-test		F-test		T-test	
	F	F_{crit}	Statistic	T_{crit}	F	F_{crit}	Statistic	T_{crit}	F	F_{crit}	Statistic	T_{crit}
A	1.02	1.98	1.110	2.617	2.04	1.98	3.625	2.704	4.39	1.98	2.069	2.704
AA	1.00	3.29	0.292	2.660	6.37	3.29	0.316	2.819	1.08	3.13	1.674	2.660
B	1.78	9.6	0.947	3.106	1.42	9.6	0.008	3.106	2.42	9.6	1.496	3.106

For Project 61009, statistical analyses revealed that, generally speaking, the contractor data and the KYTC verification data were similar. There were only a few isolated cases that did not follow this general trend. It must be noted that statistically significant cases must be followed up by an examination of the means, which are reported in these tables. Such an examination may reveal that some of these statistical significant cases may not have serious performance consequences.

5.3.2.3 Summary of QC/QA Statistical Data Analysis

The Kentucky QC/QA data which were provided to the research team, either directly (KYTC Division of Materials) or indirectly (KMIMS), were carefully examined. For asphalt projects, some air content data showed a statistically significant difference between the contractor reported data versus the KYTC verified data. Obviously, HMA air voids, VMA, and density are interrelated and this can easily confound statistical comparisons. However, the analyses for both asphalt and concrete revealed that the contractor reported data and the KYTC verified data were generally similar, and they appear coming from the same population. This is very encouraging to know, and it certainly adds confidence to the Kentucky QC/QA program.

Regarding the PCCP projects, it was found that the KMIMS data were mostly incomplete or lacking. This situation is not unique to Kentucky; most DOTs are data rich, but unfortunately information poor. It is critical for the KYTC to move toward a user friendly and retrievable project databank system. Currently, the KYTC is implementing the SiteManager program, which is a comprehensive client/server based construction management tool. It is hoped that SiteManager will allow efficient project data recording, tracking, and retrieval.

Chapter 6 - State DOTs Survey and Responses

Based upon the experience obtained from the Kentucky Transportation Cabinet interviews, a nationwide DOT survey was developed. Five different surveys were developed from the Kentucky basic questionnaire, and they were deigned to address the following specific items: portland cement concrete pavements (PCCP), structural portland cement concrete (SPCC), Hot Mix Asphalt (HMA), Aggregate Base, and Soil and Embankments. Each of the five different surveys included the properties that could be tested and the pay factors that are typically used for each material. These surveys can be seen in Appendix D. The surveys were developed to resemble the surveys which were employed used in NCHRP Synthesis 346 (Hughes, 2005), but also they were deigned to gather other quantitative as well as qualitative data. The surveys included multiple choice, Likert scale, and open-ended questions. An individual from each state DOT was identified as a point of contact for that DOT. This person then identified the most appropriate person within their organization for completing specific surveys relative to the QC/QA material specification. Of the 50 states, only 44 contacts were successful, and the surveys were sent in Microsoft Word format via email to the contact persons, or in some instances to the state DOT personnel that was recommended as the most knowledgeable about their QC/QA system. Of the 44 states that received surveys, 30 states returned responses. The overall response rate for states that responded was 66 percent (Table 6.1). The state DOT survey responses in this report are presented in accordance with three distinct sections of the surveys, and are further divided into sections to represent the five construction types: HMA, PCCP, Structural PCC, Aggregates, and Soil Embankment. Trends, specification similarities, and important issues were highlighted throughout the different sections. When appropriate, the responses from the surveys were compared and contrasted with the results of the NCHRP's Synthesis 346 (Hughes, 2005).

Table 6.1. State DOTs' Survey Responses

Agency	Hot Mix Asphalt	Portland Cement Concrete Paving	Structural Portland Cement Concrete	Aggregates	Soil and Embankment
Alabama	X				
Arizona	X	X	X	X	X
Colorado	X	X			
Connecticut	X				
Delaware	X			X	
Florida	X	X		X	X
Idaho	X				
Indiana	X	X	X		
Iowa	X	X			
Kansas	X	X			
Kentucky	X	X	X	X	X
Maine	X		X		
Minnesota				X	X
Mississippi	X				
Missouri	X	X			
Montana	X	X	X	X	
Nebraska	X				
Nevada		X			
New Jersey	X				
New York	X			X	X
North Dakota	X				
Ohio			X		
Oklahoma	X	X			
Oregon	X	X	X	X	X
South Carolina	X				
South Dakota	X				
Texas	X				
Vermont	X				
Virginia	X			X	
West Virginia	X	X	X		
TOTAL = 30	***27***	***13***	***8***	***8***	***6***

6.1 Overall Management of QC/QA Specifications

This section of the survey sought to identify the agencies that have modified their QC/QA specifications to make them more responsive based upon their experience. Activity in this area demonstrates a commitment on the part of the DOT to continuous improvement. The other important aspect of QC/QA specification management that the survey focused on was the extent to which statistics were employed in data analysis and payment calculations. The FHWA's Evaluation of Procedures for Quality Assurance Specification study revealed that the highest priority topic as reported by the agencies was verifying or validating the contractor's and agency's test results (FHWA, 2004). FHWA's study recommended the use of the AASHTO Appendix H Method (*t-test*) for verification of the total process in order to identify any differences between the contractor and the DOT test results.

6.1.1 Hot Mix Asphalt

A total of 27 DOTs, including KYTC, responded to the Hot Mix Asphalt (HMA) QC/QA specification survey. The durations of implemented HMA QC/QA specifications ranged from 16 years to 5 years. The survey responses revealed that for all the responding agencies, only 19 have conducted some type of significant modification to their HMA QC/QA specifications since its implementation. The most notable modifications, listed in order of most modified to least modified, are:

1. Frequency of testing;
2. Test method;
3. Certification of individuals to do testing;
4. Pay factor adjustments;
5. Switching to PWL; and
6. Changing the type of specification.

There was no clear relationship between the type of modification or number of modification to the duration of implementation. Figure 6.1 shows the distribution of modifications made by the agencies. Eleven agencies changed their frequency of testing, ten changed their test methods, seven changed the certification type, four made pay factor adjustments, four switched to using PWL for quality acceptance measure, and four changed the specification type to end-result specifications.

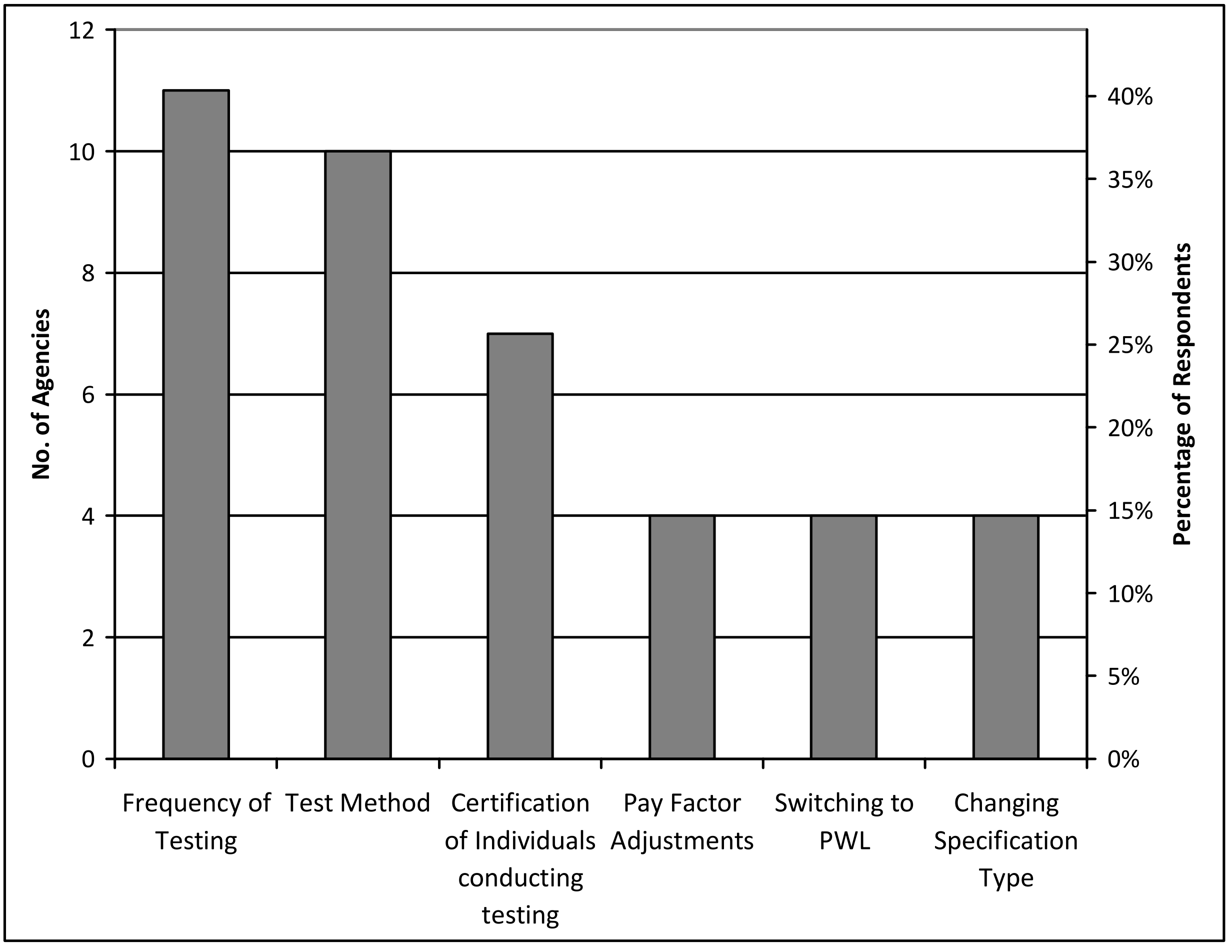


Figure 6.1: Modifications made to HMA QC/QA Specifications (Total Responses=27)

The results show that the frequency of testing and test method are the most common modifications being made. This suggests that the DOTs are increasing the frequency of testing and changing the test methods to reduce the risk of making incorrect decisions. Other modifications include adopting an equation for calculating incentive and disincentive payment instead of using tables, tightening the specification limits, clarifying the dispute resolution process, and fine tuning the material properties to be tested for QC and QA. A majority of the agencies reported that the modifications were done between one to four years after implementation, while two agencies clearly stated modifications were ongoing.

Of the 27 states that responded to the HMA survey, 17 reported that they had applied statistical methods to their HMA QC/QA data. The most popular statistical test was the t-test, which was sometimes conducted along with the F-test or Analysis of Variance (ANOVA). This may have been prompted by AASHTO and FHWA reports in recent years. The other tests used, listed in order of popularity:

1. F-test;
2. ANOVA;
3. Paired t-test; and
4. 1 to 1 comparison.

Table 6.2: Frequency of Statistical Analyses used by DOTs

Statistical Test Method	Number of Agencies
t-test	12
F-test	10
ANOVA	6
1 to 1 comparison	1
Paired t-test	1

The most popular HMA properties which were used in the statistical analysis were:

1. Air Voids;
2. Density;
3. Gradation;
4. Asphalt Content; and
5. Void in Mineral Aggregate (VMA).

Some states also used Film Thickness, Dust/Asphalt Ratio, Fine Aggregate Angularity (FAA), and Tensile Strength Ratio (TSR).

Table 6.3: Number of DOTs Using Various HMA Tests.

Hot Mix Asphalt Property	Number of Agencies
Air Voids	12
Density	12
Asphalt Content	9
Gradation	5
Voids in Mineral Aggregate (VMA)	5
Film Thickness	1
Dust/Asphalt Ratio	1
Fine Aggregate Angularity (FAA)	1
Tensile Strength Ratio (TSR)	1

Questioning DOTs regarding the outcome of their statistical testing revealed that only four agencies found occasional significant differences in the contractor QC data versus the DOT verification data. The Colorado DOT personnel specified that differences were found "at times" after conducting statistical analysis using ANOVA. In order to identify the source of significant difference, CDOT tries to identify the problem area through check testing (Colorado Procedure 13). Check testing involves comparing the testing equipment and the personnel (DOT engineer and contractor personnel) that will be used according to the contract. Testing is done on at least five split samples. In the case of bituminous pavements density, testing must be done on seven split samples to correlate nuclear with gauges.

Overall, approximately 70 percent of the agencies that responded to the survey reported a regular cycle of QC/QA specification modification. Finally, all of the DOTs that participated in this survey reported that their HMA QC/QA specifications have proven to be effective.

6.1.2 Portland Cement Concrete Pavement

The portland cement concrete pavement (PCCP) QC/QA specification survey had a total of 13 responses. According to the NCHRP's Synthesis 346, only 16 of their 40 respondents use a QC/QA program for concrete in which the contractor conducts the day-to-day quality and process control and the DOT conducts the verifications testing (Hughes, 2005). By contrast to the NCHRP Synthesis 346, only 43 percent of the 30 agencies responded to University of Kentucky's PCCP survey, while 40 percent responded to NCHRP's survey. However, the outcome trends were similar.

Responding DOTs reported that their experience with the QC/QA PCCP programs ranged from 14 years to 4 years. Of the 13 responding agencies, six reported that they have conducted a significant modification to their PCCP QC/QA specifications since its implementation. The most notable modifications include:

1. Frequency of testing;
2. Test methods; and
3. Certification of individuals to conduct testing

Figure 6.2 shows the distribution of modifications made to the PCCP QC/QA specifications. Four agencies changed their frequency of testing, three changed their test methods, two changed the certification type, and one switched to using PWL for quality acceptance purposes.

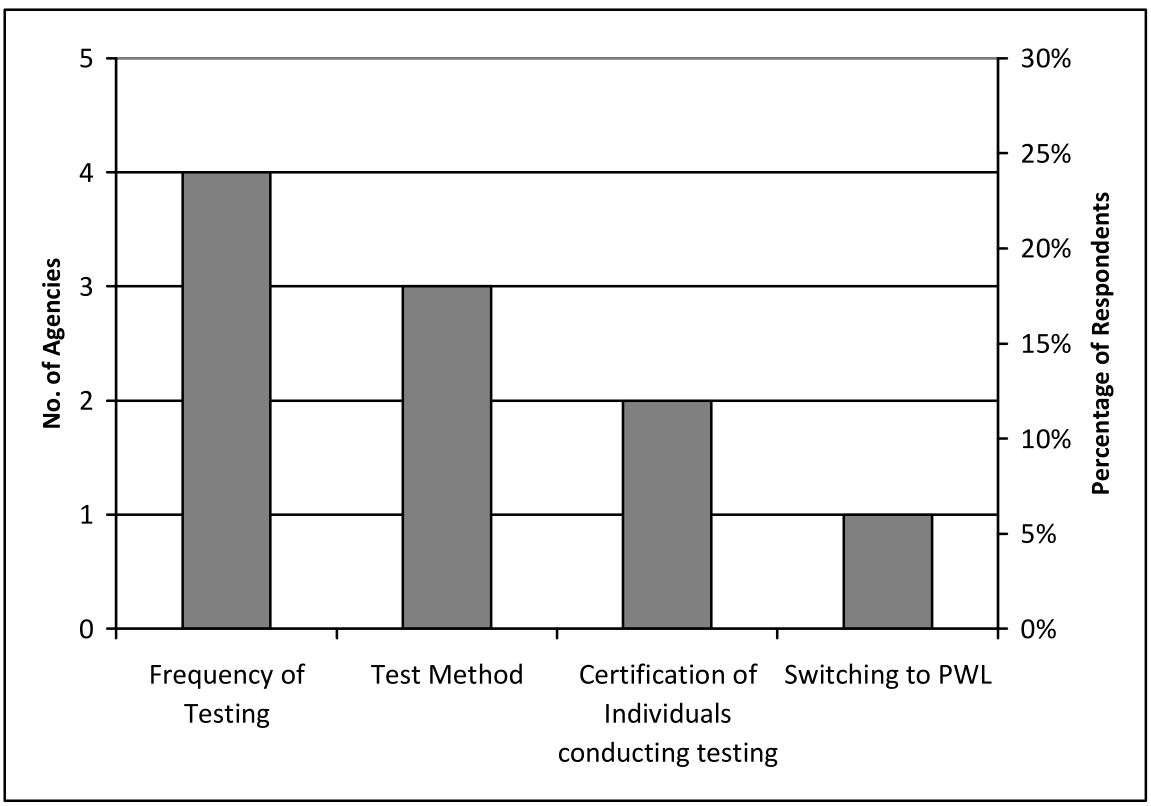


Figure 6.2: Modifications made to PCCP QC/QA Specifications (Total responses=13)

Of the 13 agencies that responded, only four responded that they have conducted statistical analyses on the PCCP QC/QA data. These agencies reported using the F-test, t-test, Analysis of Variance (ANOVA) and the paired t-test. Only one of the agencies reported discovering a significant statistical difference in the PCCP QC/QA data, however, the source of the difference was not found. The data used for statistical analyses were based upon entrained air, temperature, water-cement ratio, compressive strength, flexural strength, sand equivalency, and thickness. The most popular parameters were:

1. Compressive strength;
2. Water-cement ratio;
3. Entrained air; and
4. Thickness.

The number of states with an implemented PCCP QC/QA program is rather small, less than 50 percent of the agencies that responded to the surveys. Approximately 45 percent of the agencies have conducted some type of major modification to their PCCP QC/QA specifications.

6.1.3 Structural Portland Cement Concrete

The structural portland cement concrete (SPCC) QC/QA specification survey had a total of eight responses. According to the NCHRP's Synthesis 346, only 17 of their 40 respondents use a QC/QA program (Hughes, 2005).

The survey revealed that the age of SPCC QC/QA programs ranged from 8 to 14 years. Of the eight agencies that responded, three reported that they have conducted some type of significant modification to their SPCC QC/QA specifications since its implementation. The most notable modifications were the frequency of testing and the test methods. Figure 6.3 shows the distribution of modifications made to the SPCC QC/QA specifications. Two agencies changed their frequency of testing, two changed their test methods, one changed the certification type, one made pay factor adjustments, one adjusted the specification limits, and one clarified the responsibilities of the contractors and agency.

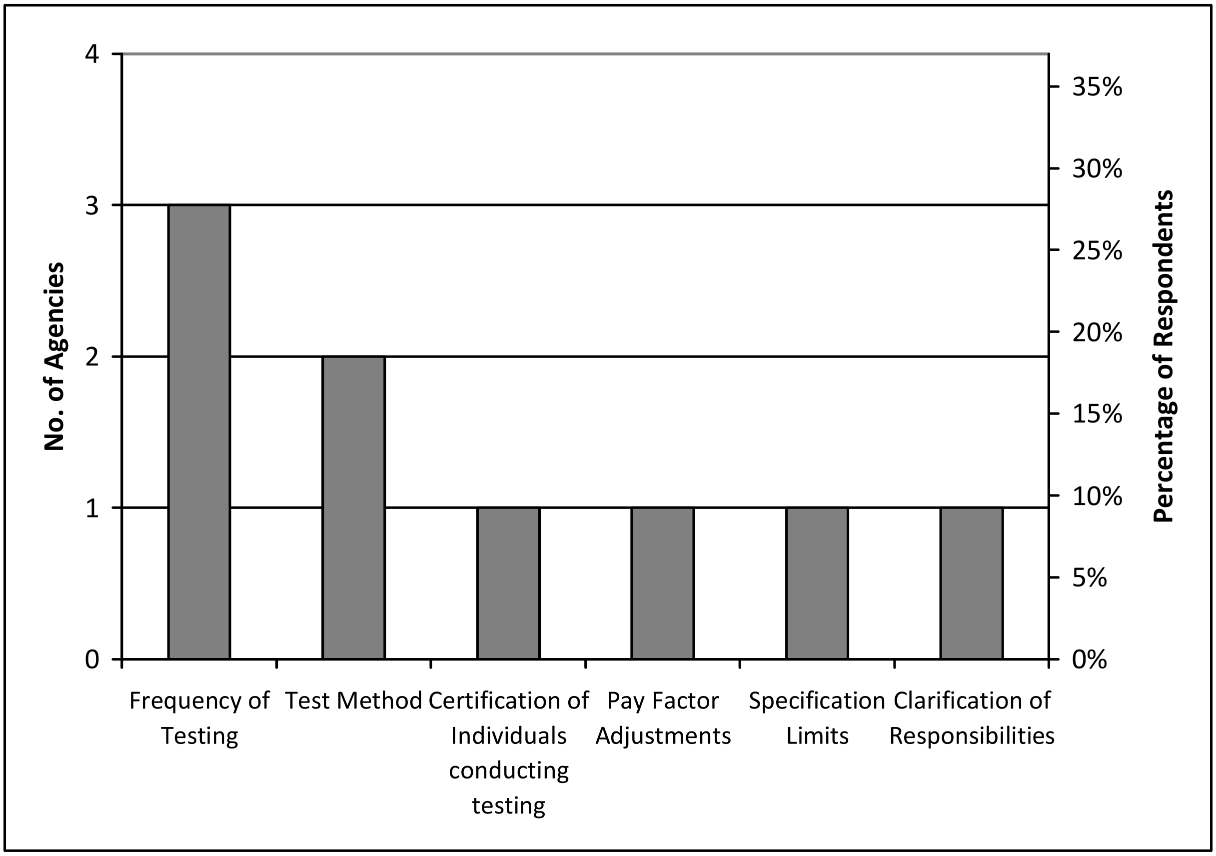


Figure 6.3: Modifications made to SPCC QC/QA Specifications

Of the eight agencies that responded, three responded that they have conducted statistical analyses on the SPCC QC/QA data. The agencies reported using the F-test, t-test, and Analysis of Variance (ANOVA). None of the agencies reported discovering a significant statistical difference in the SPCC QC/QA data. The properties used for statistical analyses included:

1. Entrained air;
2. Temperature;
3. Water-cement ratio;
4. Compressive strength;
5. Slump; and
6. Gradation.

The number of states that have implemented SPCC QC/QA specification was small, less than 50 percent of the agencies that responded to the surveys. This is also similar to NCHRP's Synthesis 346, where 16 of the 40 states that responded had implemented SPCC QC/QA specification. Approximately 40 percent of the agencies have conducted some type of major modification to their SPCC QC/QA specifications and conducted statistical analyses on the SPCC QC/QA data.

6.1.4 Aggregates

The number of respondents with an Aggregates QC/QA program was rather small, only eight. However, the Florida DOT (FDOT) was very helpful, and they provided a tremendous insight into their QC/QA program. Twenty one DOTs out of the 45 that responded to NCHRP's Synthesis 346 survey, reported having a QC/QA program.
Out of the eight agencies who responded to the University of Kentucky survey, five have conducted some type of modification to their Aggregate QC/QA specification. Such modifications included:

1. Frequency of testing;
2. Test methods; and
3. Certification requirements.

FDOT provided a list of the significant modifications made to their Aggregate QC/QA specifications, which can be seen below:

1. Streamlining approval process, modifying the number of samples;
2. Allowing out of country sources to ship material into Florida and have the contractor perform all mine related tests in Florida;
3. Allowing direct shipments from out-of state mines to project if Contractor assumes risk of not letting the Redistribution Terminal perform additional gradation test;
4. Switching from Marshall to Superpave sieves;
5. Changing PWL system for Superpave aggregate;
6. Increased allowable minus 200 for granite at source from 1.75 percent to 2.5 percent;
7. Added Independent Assurance program for Technician and Laboratory qualifications.
8. Added penalties for fraud;
9. Changed approval status that mines are either approved or not. Changing the approval status gave FDOT legal avenue to put conditions on approved mines without changing approval status;
10. Standardized test frequencies for rail and ship terminals to eliminate District inconsistencies;
11. Added requirement for on-site computer with ability to do PWL calculation; and
12. Added allowance to restart the PWL clock if producer identifies, documents, and reports failing data to FDOT.

The FDOT has made numerous changes to their specifications since its implementation in 1983. The different changes made to the specifications were aimed at quality and legal issues, and their training updated their personnel regularly.

Three states reported that they use statistical tools in their aggregate QC/QA data. Such data included gradation, percent cubical, minus #200 sieve, specific gravity, aggregate fractured faces, and Los Angeles Abrasion. FDOT reported that they have at times found significant difference after conducting a statistical analysis. The reason given is usually poor testing practices. The FDOT contact person provided his insight on this issue below:

> "*FDOT's response is to teach management and technicians how to use Quality Control charts as invented by Dr. Shewhart and made famous by Dr. Deming. Most QC technicians have no idea of the importance of their role, nor what to do with data. They*

want to do a good job, but are trained by their company to just run a test, not to provide feedback on trends or process behavior.
Management has not until recently understood the concepts either. A commercial computer program has taken the mines out of the dark ages and allows them to track statistical compliance and view charts. Many of our producers, (all of our big ones) have the technology. By encouraging the reporting of all data, without fear of retribution, we can negotiate with the mines on disposition of material and evaluation of PWL compliance provided they fix the problem (eg. Broken or wrong-sized screen deck in place). I believe we have seen a turn-around in attitudes. At one mine, maintenance and production go to the QC office to see how their actions are affecting the product – unheard of until recently! Requiring Qualifications for technicians has 'professionalized' them and increased their level of pride."

The information provided by FDOT offers some guidance into the macro view of QC/QA in general, and aggregate quality specifically. It also highlights the importance of having the contractor's personnel understand the importance of what they are doing with data and how it affects the final product that the agency purchases with tax payers' money.

6.1.5 Soil and Embankment

The soil and embankment survey had responses from six agencies. This number of responses is less than 50 percent of the NCHRP Synthesis 346, which had 16 responses of states with a QC/QA program. Due to this small response rate, little information could be gleaned from the data.

Of the six agencies that responded only three reported that they have conducted some type of significant modification to their soil and embankment QC/QA specifications. Their modifications included frequency of testing and the responsibility for acceptance and verification. The response for statistical analysis was even smaller, with only one agency reported any statistical analysis on the soil and embankment data, which was limited to soil density.

6.2 Survey of QC/QA Administrations

This portion of the survey focused on the roles and responsibilities of various parties within a QC/QA regime, and the overall experience of various state DOT agencies.

6.2.1 Hot Mix Asphalt

All 27 agencies that responded to the survey reported that the contractor is responsible for conducting all HMA QC tests. A summary of the QC/QA roles and responsibilities for various parties can be found in Table 6.4 and Figure 6.4.

Table 6.4: HMA QC/QA Roles and Responsibilities

Responsibility	Contractor	DOT	Both
QC Testing	27	0	0
QC Tests Evaluation	1	4	3
Initiate Corrective Action	4	4	1
Evaluation and Initiate Corrective Action	14	2	2

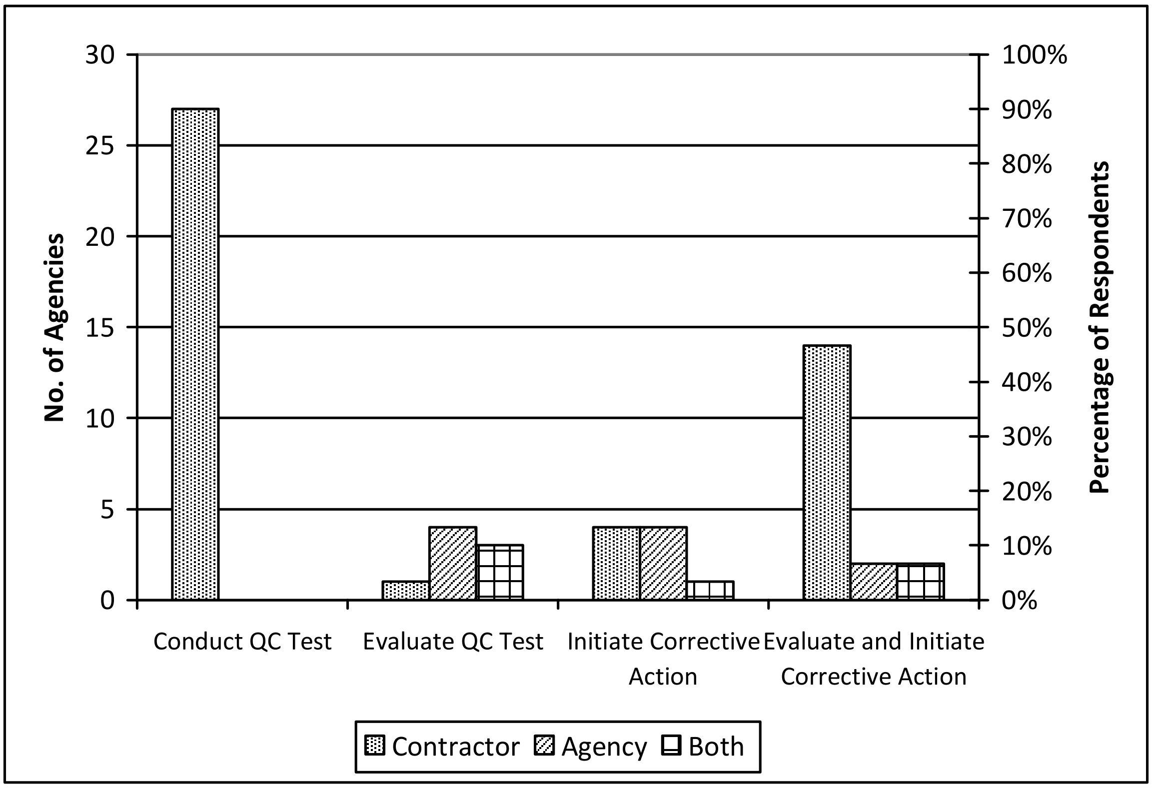


Figure 6.4: Summary of QC/QA responsibilities for HMA projects.

The most popular HMA properties that are tested for QC and QA are:

1. Voids in Mineral Aggregate;
2. Asphalt Content;
3. Air Voids;
4. Density;
5. Gradation; and
6. Specific Gravity.

These properties are listed based on the top six tested for both QC and QA in no particular order. The number of agencies that conduct tests on these properties for QC/QA can be seen in Figure 6.5.

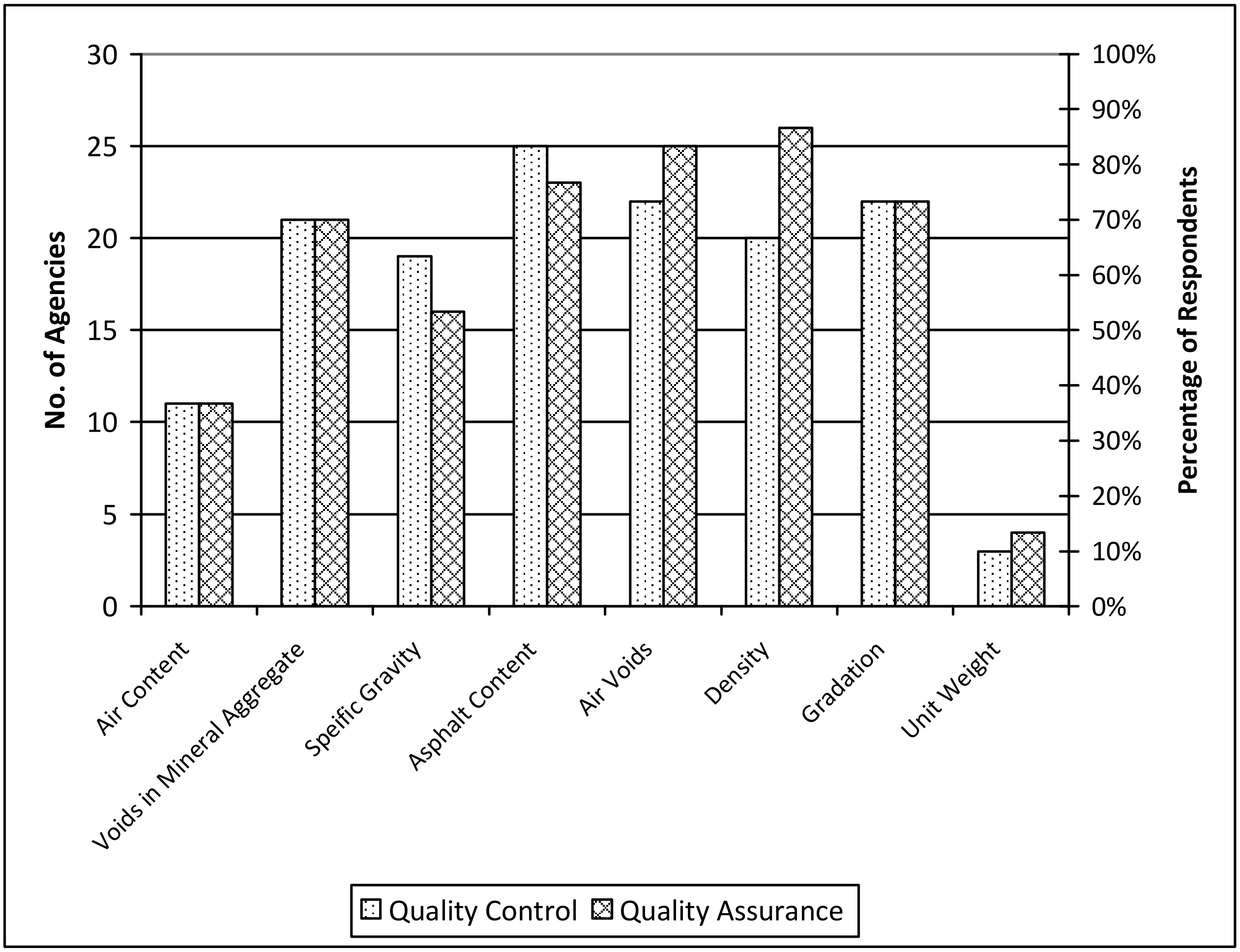


Figure 6.5: HMA Properties Tested for QC and QA

In comparison to the other agencies, the Kentucky Transportation Cabinet tests voids in mineral aggregate, asphalt content, and air voids for QC. The cabinet also tests these properties as well as density for QA.

Agencies also reported testing additional properties, such as: film thickness, filler to bitumen ratio, voids filled with aggregates, tensile strength ratio, dust to asphalt ratio, fine aggregate angularity (FAA), coarse aggregate angularity (CAA), bulk specific gravity, percent reclaimed asphalt pavement, and mix moisture. All of the properties and the number of agencies that test these properties can be seen in Table 6.5.

Table 6.5: HMA Properties Tested for QC/QA by DOTs

Property	QC	QA	Property	QC	QA
Air Content	**11**	**11**	Film Thickness	**1**	**0**
Voids in Mineral Aggregate	**21**	**21**	Voids Filled with Asphalt	**2**	**2**
Specific Gravity	**19**	**16**	Tensile Strength Ratio	**2**	**1**
Asphalt Content	**25**	**23**	Dust-to- Asphalt Ratio	**3**	**3**
Air Voids	**22**	**25**	Fine Aggregate Angularity	**2**	**2**
Density	**20**	**26**	Coarse Aggregate Angularity	**2**	**2**
Gradation	**22**	**22**	Bulk Specific Gravity	**1**	**1**
Unit Weight	**3**	**4**	% Reclaimed Asphalt Pavement	**1**	**1**
F/B Ratio	**1**	**1**	Mix Moisture	**1**	**0**

The DOT HMA verification testing is done to verify the contractor QC data. The survey revealed that the DOT verification testing averaged around one DOT test for every three to four contractor tests. Figure 6.6 shows the distribution of QC and QA testing percentages for various DOT agencies. The highlighted points represent the Kentucky's QC and QA percentages in comparison to the other agencies.

The HMA verification testing is sometimes outsourced to testing firms. Seventeen of the 27 responding agencies use only in-house technicians, and ten use both in-house and outside testing firms. Six of the responding agencies that reported using outside testing firms used their own state certifications to determine the qualification of all technicians, while two used AASHTO and ACI certifications. Three of the states reported using the New England Transportation Technician Certification Program (NETTCP), a regional certification used by the New England states. Florida reported using AASHTO and the Florida Construction Materials Engineering Council (CMEC) for technician qualification.

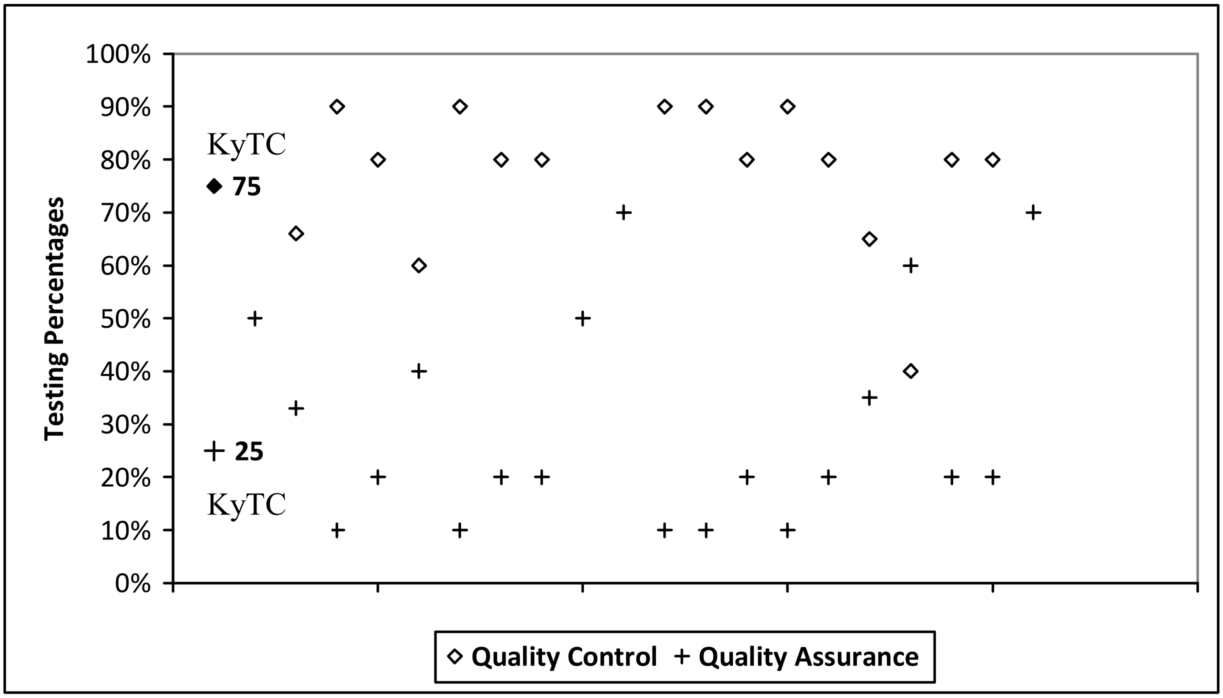


Figure 6.6: Quality Control and Quality Assurance Testing Frequencies for HMA.

Sixty eight percent of the responding DOTs reported that the verification tests are purely for verification and not pay determination. All of the states reported that they conduct independent assurance testing in-house, and only one state reported that independent assurance was done by a consulting firm rather than by the state. Fifteen responding agencies reported using percent within limits (PWL) on pilot asphalt projects or they are planning on implementing it in 2009. Ten states reported using tolerance, five using range and average, and four reported using standard deviation. The NCHRP Synthesis 346 also reported that PWL was also the most used quality measure for acceptance for HMA (Hughes, 2005). Percent within limits is regarded as a more rigorous statistical system to be used in QC/QA specifications (Focus, 2006). The percent within limits combines the effects of average and standard deviation into one single number; Kentucky uses average, tolerance and range.

The next question on the survey asked whether or not the agency has a central database. This question was answered by 24 of the 27 states. Eleven reported that they have a central database, another eleven reported that they did not. One DOT reported that data was kept on spreadsheets for each individual project, and one reported using a stand alone program. Nine of the eleven states that do have a central database reported that both the agency and contractor personnel are not required to be familiar with the database, and the remaining two reported that they both do have to be familiar with the database. Ten of the eleven states reported having a standard protocol for recording project data into the database, while one DOT reported that it had no specific protocol. The agencies that used specific data recording protocols reported that they had a satisfactory data management experience.

Twenty one of the 25 agencies reported using pay incentives as well as disincentives in their HMA QC/QA specifications. The remaining four states did not reply to the question. The most popular characteristics that were used for pay adjustment were:

1. Air voids:
2. Voids in Mineral Aggregate; and
3. Density.

Table 6.6 presents a summary of pay adjustment parameters as reported by the responding state DOT agencies.

Table 6.6: HMA Characteristics Used for Pay Factors

Characteristic	No. of Agencies	Characteristic	No. of Agencies
Air Voids	16	VMA	9
Density	17	Joint Density	1
Asphalt Content	6	Gradation	7
Film Thickness	1	Binder Content	4
Compaction	1	Smoothness	1
FAA	1	D/A Ration	2
Air Content	3	VFA	1

Figure 6.7 depicts a comparison of HMA air voids requirements in Kentucky versus 26 DOTs who were randomly selected. Kentucky stands in the mid range with the other agencies on HMA air voids.

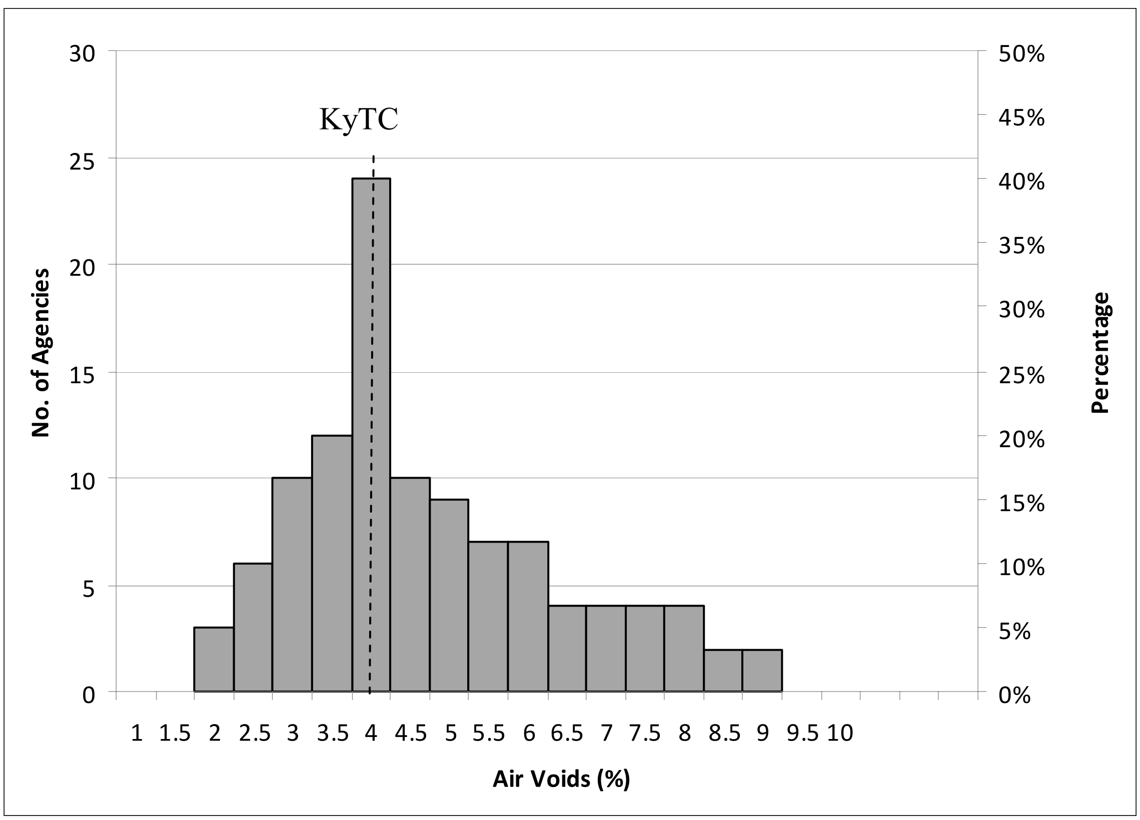


Figure 6.7: DOTs HMA Air Voids Requirements as Compared to Kentucky.

6.2.2 Portland Cement Concrete Pavement

All 27 agencies that responded to the survey reported that the contractor is responsible for conducting all PCCP QC tests. A summary of the QC/QA roles and responsibilities for various parties can be found in Figure 6.8.

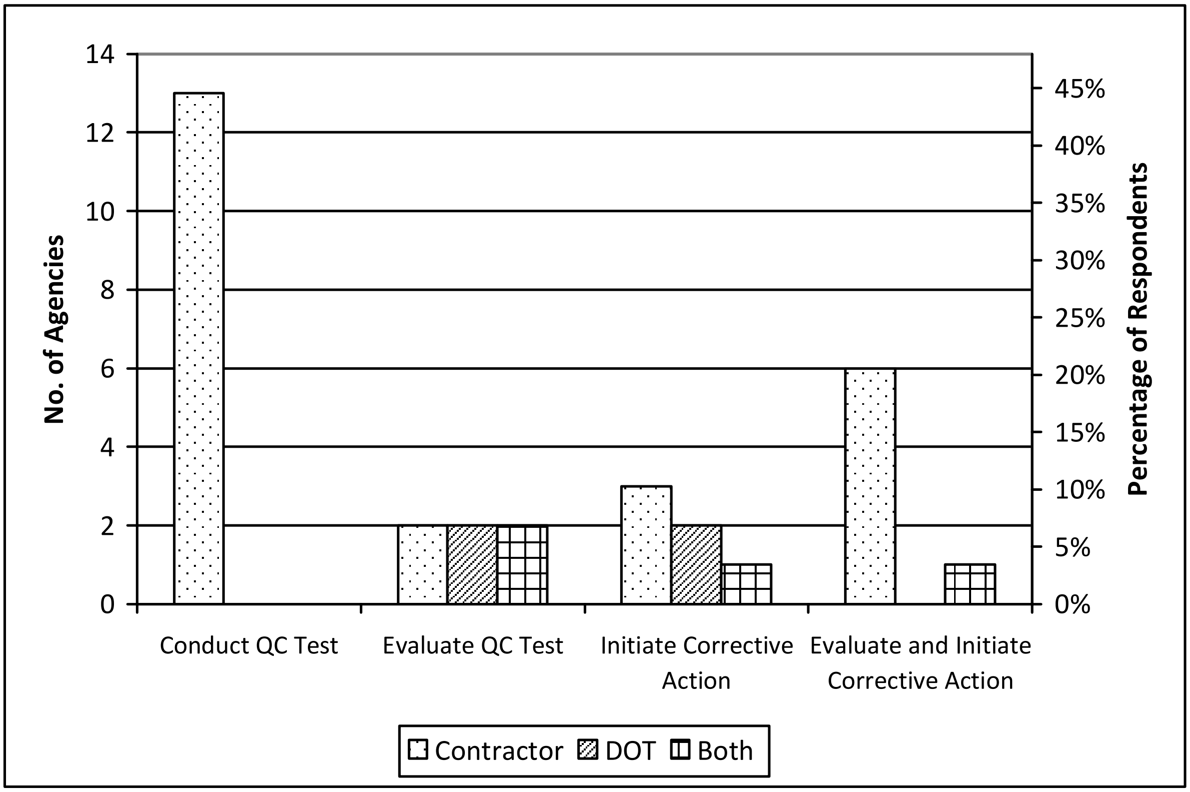


Figure 6.8: Summary of QC/QA Responsibilities for PCCP projects.

The frequency of testing for the portland cement concrete pavement QC/QA specifications is established mainly by the DOT. Twelve of the thirteen agencies reported that the testing frequency is established by the agency. Out of these twelve agencies, four of them use control charts to track and decide upon the testing frequency. Only one of the agencies allows the contractor to establish the testing frequency for QC tests.

Seven of the agencies reported that PCCP QA tests are conducted by both in-house and by outside technicians. The outside testing is done mainly by consulting firms and one agency specified that a private testing laboratory is used. Five of the agencies reported using their own state certification to determine the qualifications of outside testing firms; four reported using ACI certification, and one using AASHTO certification. Two states, are considering letting the contractor perform acceptance testing if they meet certain criteria. All of the other states are not moving to change their current QA practices.

The DOT verification testing is done to verify the contractor QC data. The survey revealed that the DOT PCCP verification testing averaged around one DOT test for every three to four contractor tests. This is similar to the HMA testing frequency. Figure 6.9 shows the distribution of QC and QA testing percentages for various DOT agencies. The highlighted numbers represent the testing frequency for Kentucky.

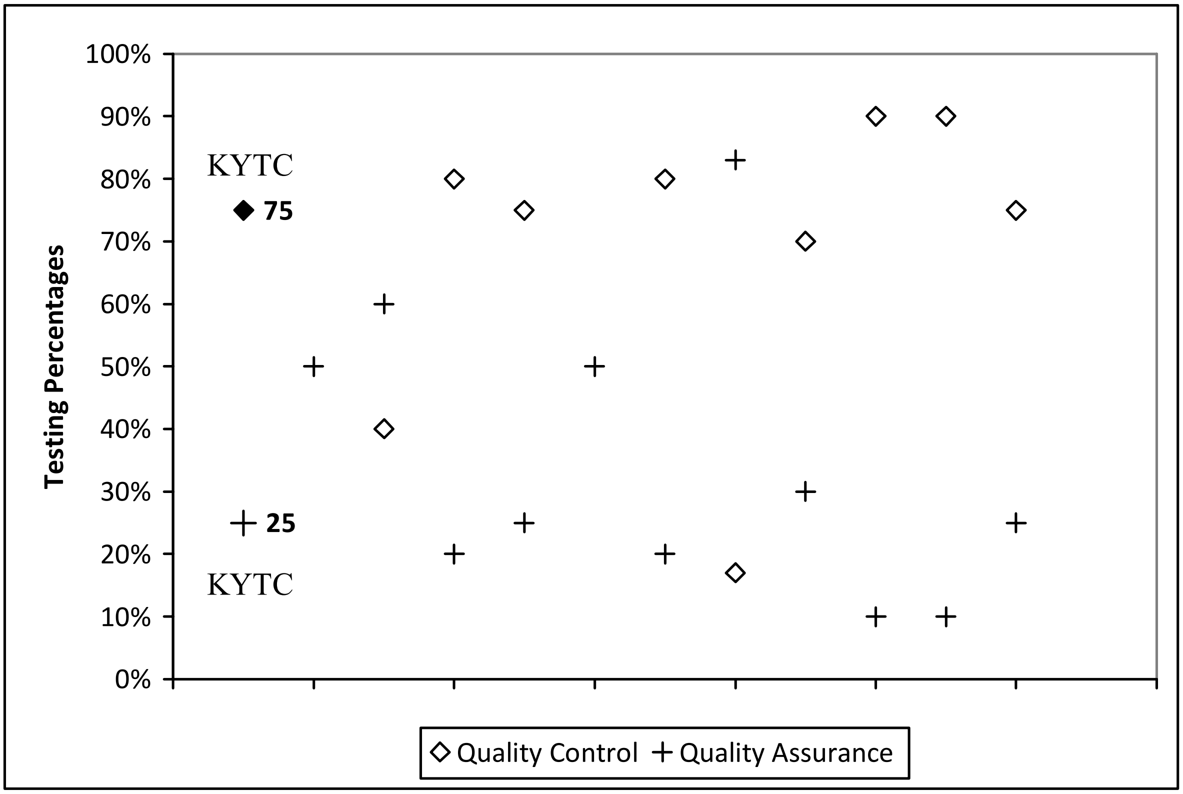


Figure 6.9: Quality Control and Quality Assurance Testing Frequencies for Portland Cement Concrete Paving.

Approximately, half of the responding DOTs reported that they use their verification data for pay purposes. Independent assurance testing was reported to be done by all thirteen responding agencies in-house. The Florida DOT respondent offered that "*We (FDOT) are modifying our Independent Assurance initiatives to include a more knowledgeable staff, both contractors and department, with an awareness of the consequences when defective activities are left unresolved.*"

The concrete pavement properties that were commonly tested for QC/QA included:

1. Air content;
2. Temperature;
3. Water-cement ratio;
4. Compressive Strength;
5. Slump;
6. Gradation; and
7. Unit Weight.

Only one agency reported using the flexural strength of concrete in their PCCP specifications. Figure 6.10 presents a distribution of various QC/QA tests as reported by the responding DOTs.

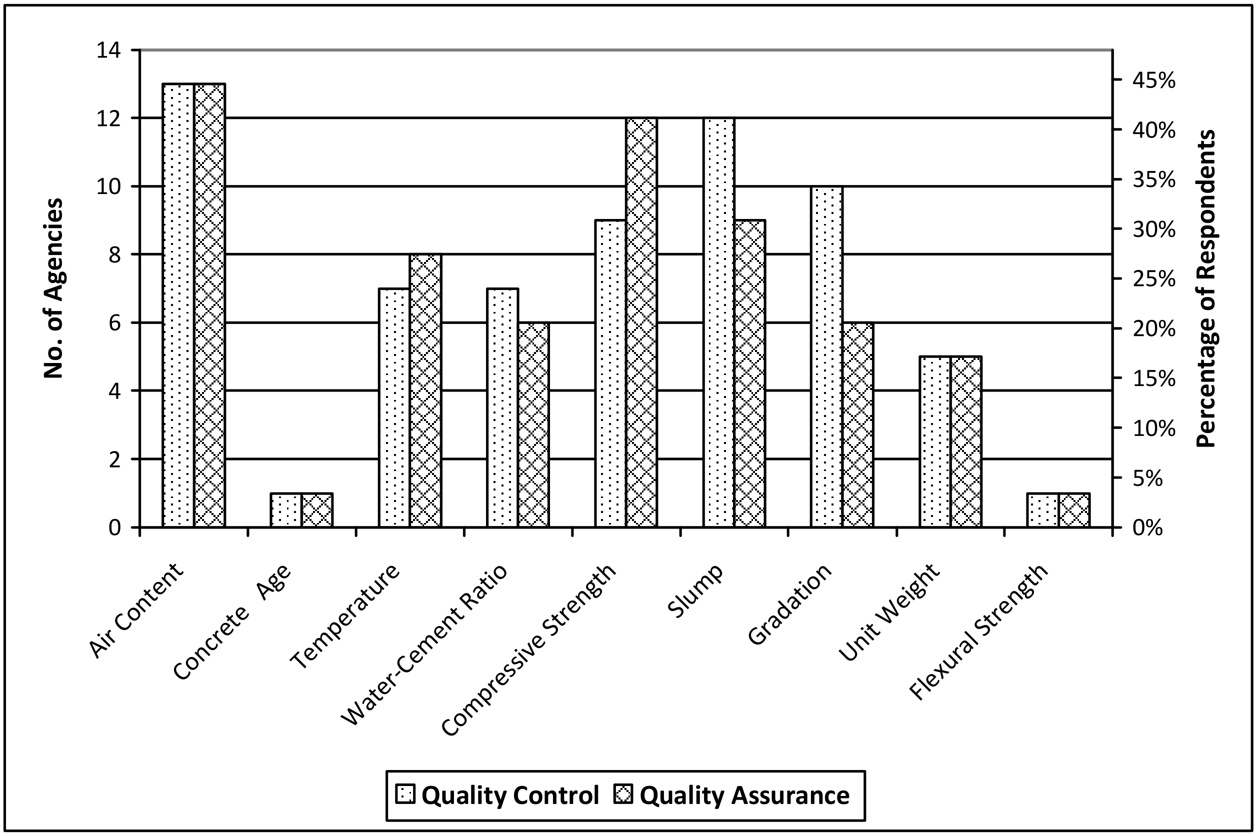


Figure 6.10: PCCP Properties Tested for QC and QA (Total Responses=13)

The quality measure mostly used for acceptance by the agencies is percent within limits (PWL). The next most popular method is average, then range, and then standard deviation. One DOT reported that the agency has its own statistical formula to measure quality for acceptance of PCCP. Four of the states reported using more that one quality measure for acceptance of the PCCP. The NCHRP's Synthesis 346 also reported that PWL was the most popular, followed by range (Hughes, 2005).

Eight of the thirteen agencies responded to the pay incentive/disincentive question on the survey. Seven agencies reported using pay incentives/disincentives in adjusting the contractors pay. The characteristics that are most often used are:

1. Thickness;
2. Compressive Strength;
3. Ride Quality; and
4. Air Content.

Table 6.7 shows the distribution of the characteristics used by the different agencies.

Table 6.7: PCCP Characteristics Used for Pay Factors

Characteristic	No. of Agencies	Characteristic	No. of Agencies
Thickness	7	Gradation	2
Compressive Strength	4	Sand Equivalency	1
Flexural Strength	2	Ride Quality	3
Fineness Modulus	1	Air Content	3

Figure 6.11 depicts a comparison between the PCCP compressive strength requirement in Kentucky versus 27 other DOTs who were randomly selected. It appears that Kentucky's requirement in this area is in the mid-range.

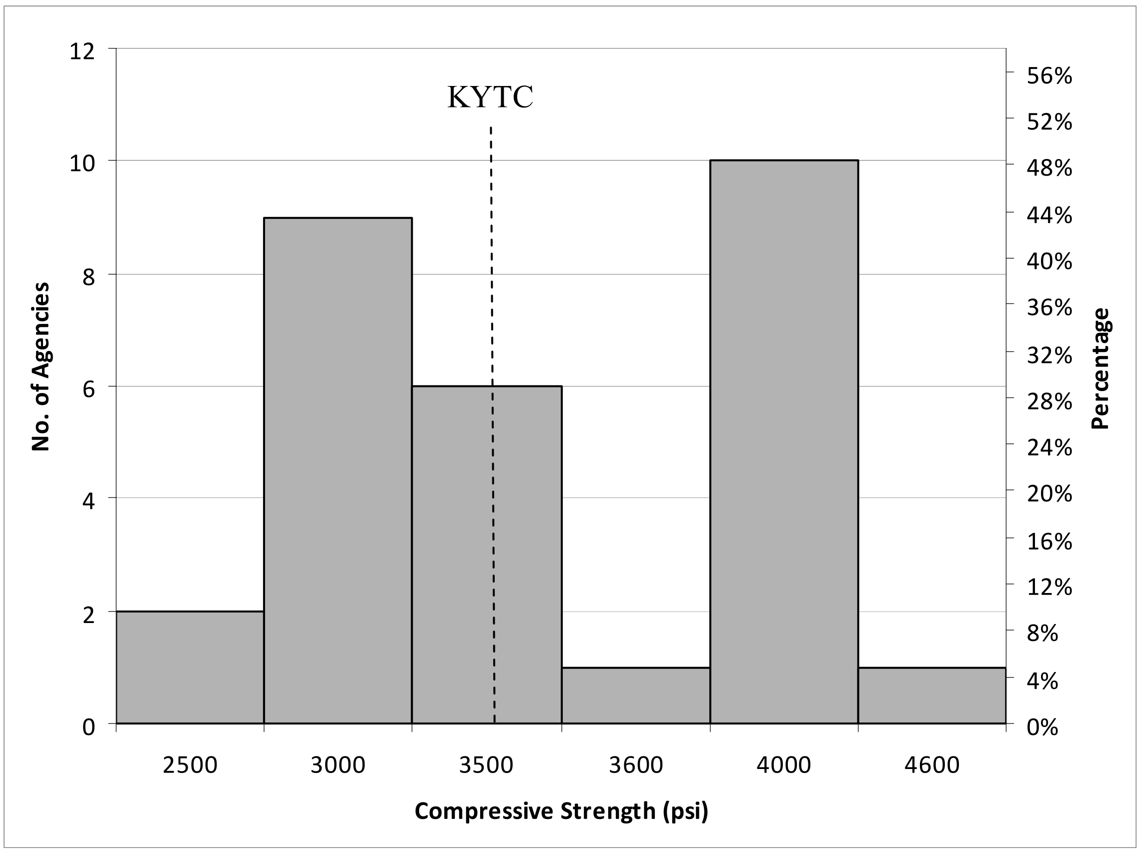


Figure 6.11: DOTs PCCP Compressive Strength Requirements as Compared to Kentucky.

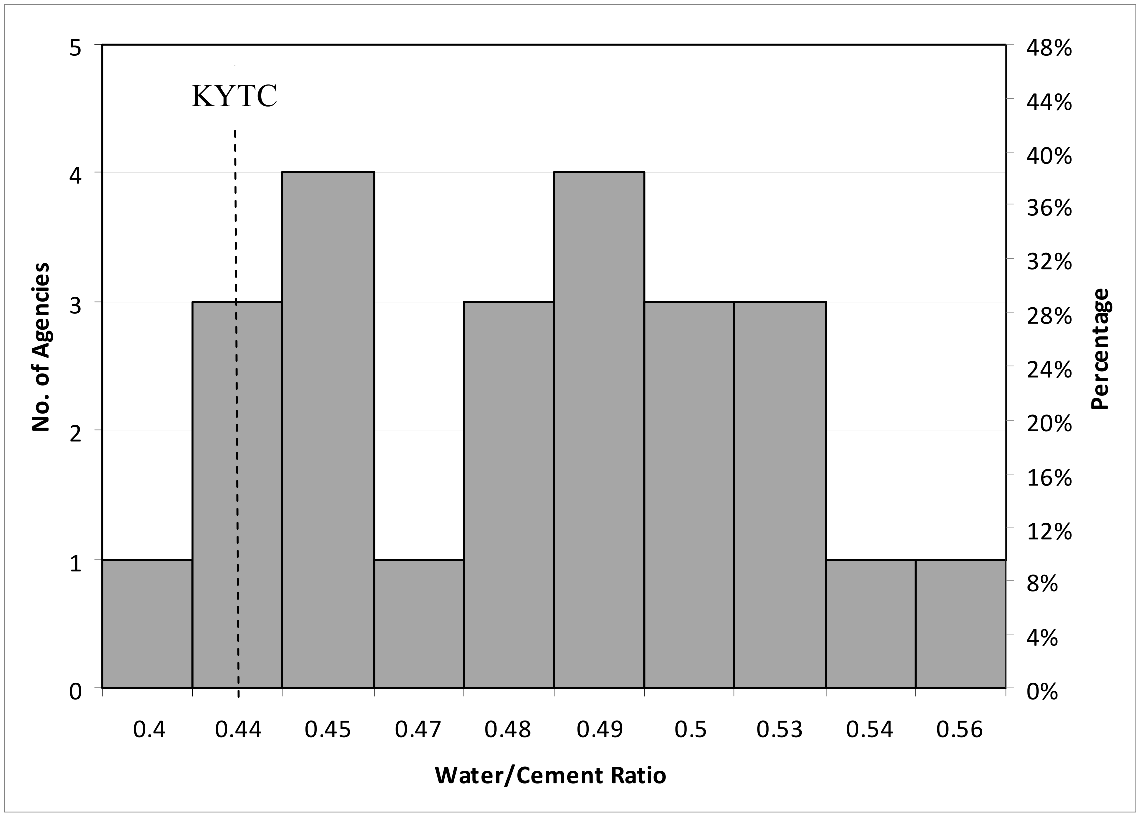


Figure 6.12: DOTs PCCP Water to Cement Ratio Requirements as Compared to Kentucky (Total = 24).

Figure 6.11 depicts a comparison between the PCCP compressive strength requirement in Kentucky versus 24 other DOTs who were randomly selected. It appears that Kentucky's requirement in this area is in the mid-range.

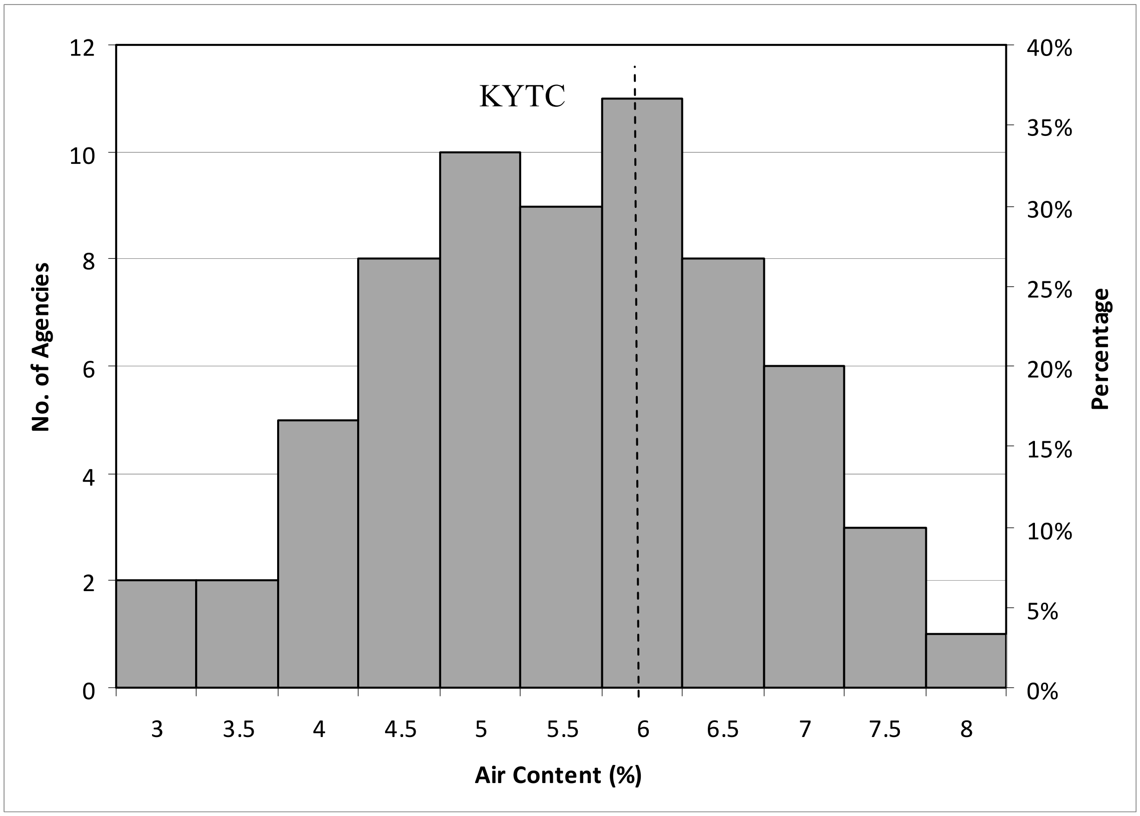


Figure 6.13: DOTs PCCP Air Content Requirements as Compared to Kentucky (Total = 20).

Figure 6.13 depicts a comparison between the PCCP air content requirement in Kentucky versus 20 other DOTs who were randomly selected. It appears that Kentucky's requirement in this area is on the high side, which would be desirable from a durability point of view.

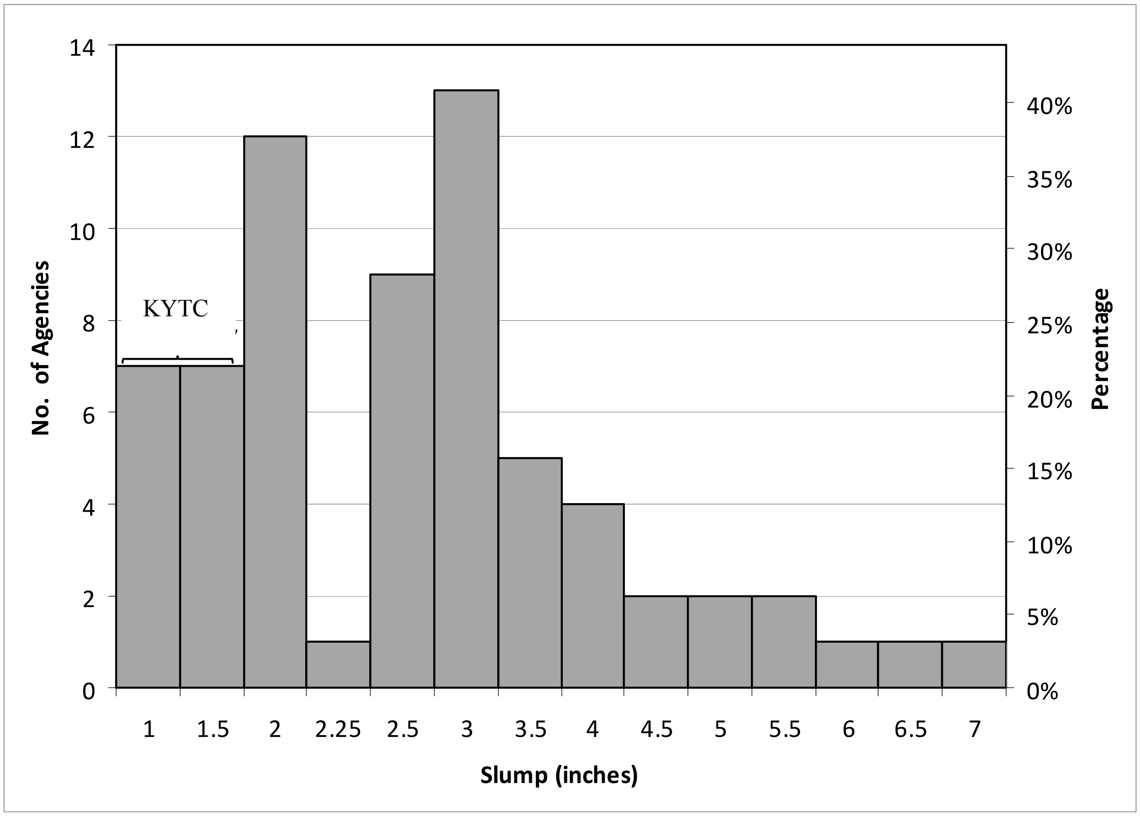


Figure 6.14: DOTs PCCP Slump Requirements as Compared to Kentucky (Total = 22).

Figure 6.14 depicts a comparison between the PCCP slump requirement in Kentucky versus 22 other DOTs who were randomly selected. It appears that Kentucky's requirement in this area is on the low side, which would be desirable in slip-form operations.

6.2.3 Structural Portland Cement Concrete

The responses from the structural portland cement concrete QC/QA survey revealed that the contractors have most of the responsibilities for testing, test result evaluation, and initiating corrective action. All eight of the agencies who responded to this section reported that the contractors are responsible for QC testing. The allocation of responsibilities are depicted in Figure 6.15.

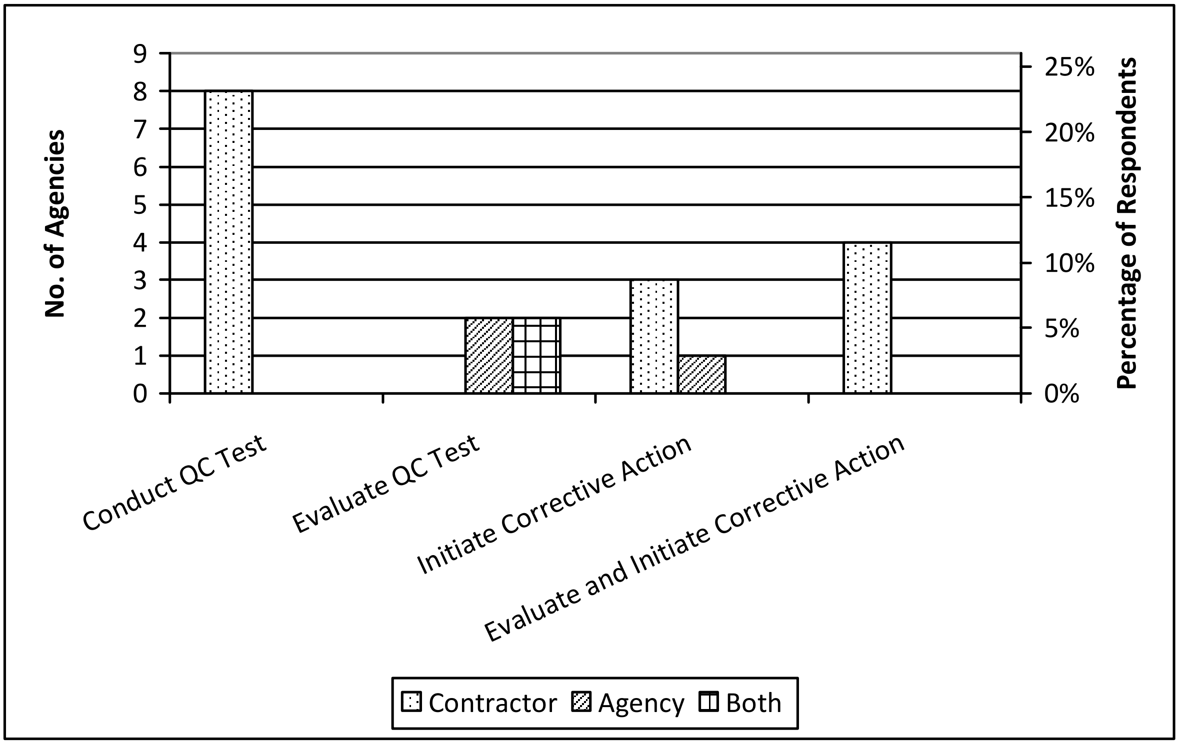


Figure 6.15: Summary of QC/QA Responsibilities for Structural PCC projects.

The frequency of testing is mainly established by the agencies with seven of the eight agencies establishing the testing frequency. Quality Assurance testing is done only in-house by six of the eight agencies and two of the agencies conduct QA testing both in-house and by consulting firms. The agencies that use consulting firms use AASHTO, ACI, and their own state certification to determine the technician qualifications. Approximately one out of every four contractor tests is verified by the DOTs. The outliers in testing frequency were one out of two at the one extreme, and one out of ten at the other extreme. The properties that are commonly used for QC/QA testing are:

1. Air Content;
2. Temperature;
3. Compressive Strength;
4. Slump; and
5. Gradation.

Occasionally other properties are also used, such as: water-cement ratio, concrete age, unit weight, yield strength, and permeability. The distribution of the structural portland cement concrete tests can be seen below in figure 6.16.

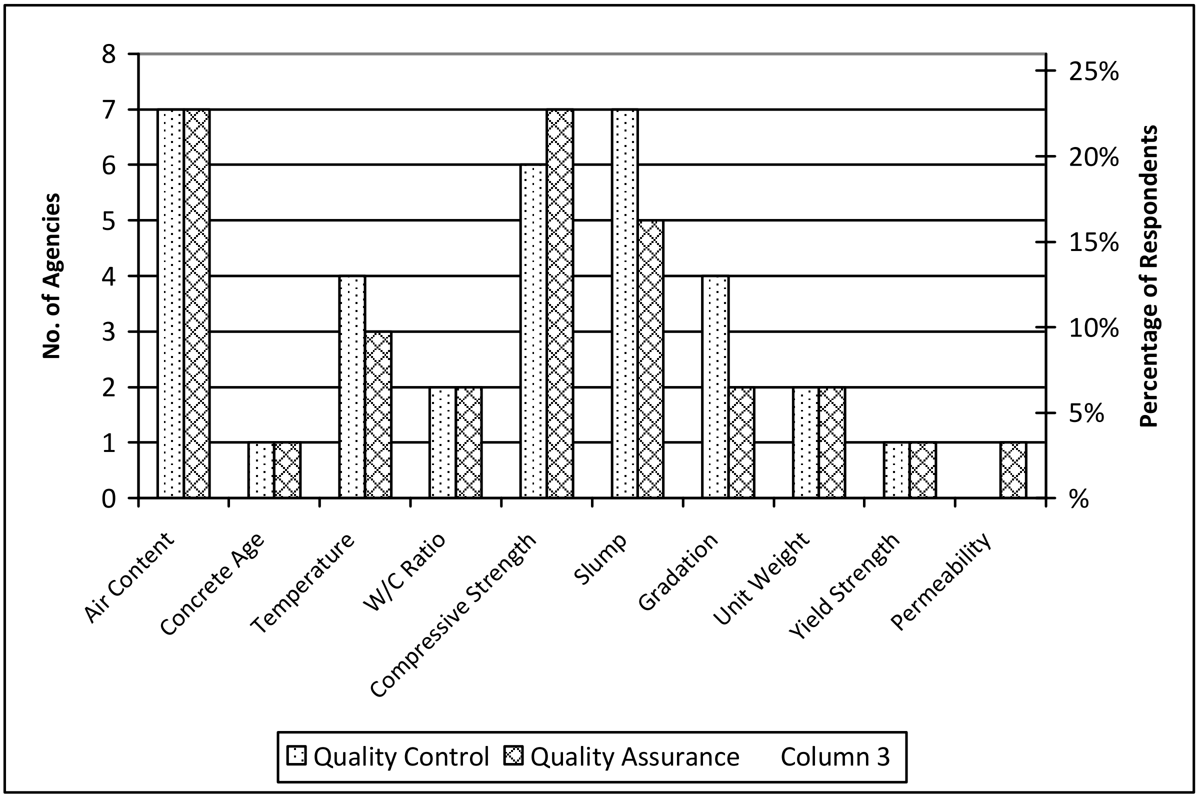


Figure 6.16: Structural PCC Properties Tested for QC and QA (Total Responses=8)

The surveys also indicated that the majority of states do not have a central database for their QC/QA structural concrete projects. The three states that indicated that they have a central database do have a standard protocol that only DOT personnel are required to follow. The KYTC responded that QC/QA concrete structures are off the specifications for the time being. Five of the responding agencies mentioned that they use pay adjustments for incentive/disincentive. The two most popular parameters for pay adjustments were:

1. Compressive Strength and
2. Air Content

Table 6.8 shows the distribution of various pay factor parameters.

Table 6.8: SPCC Characteristics Used for Pay Factors

Characteristic	No. of Agencies	Characteristic	No. of Agencies
Compressive Strength	5	Air Content	3
Thickness	1	W/C Ratio	1
Concrete Class	1	Slump	1
Permeability	1	Masonry Coating	1

Figures 6.17 through 6.20 depict comparisons between the structural concrete specifications in Kentucky versus 19 to 22 other DOTs who were randomly selected. It appears that Kentucky requirements in this are in the mid-range.

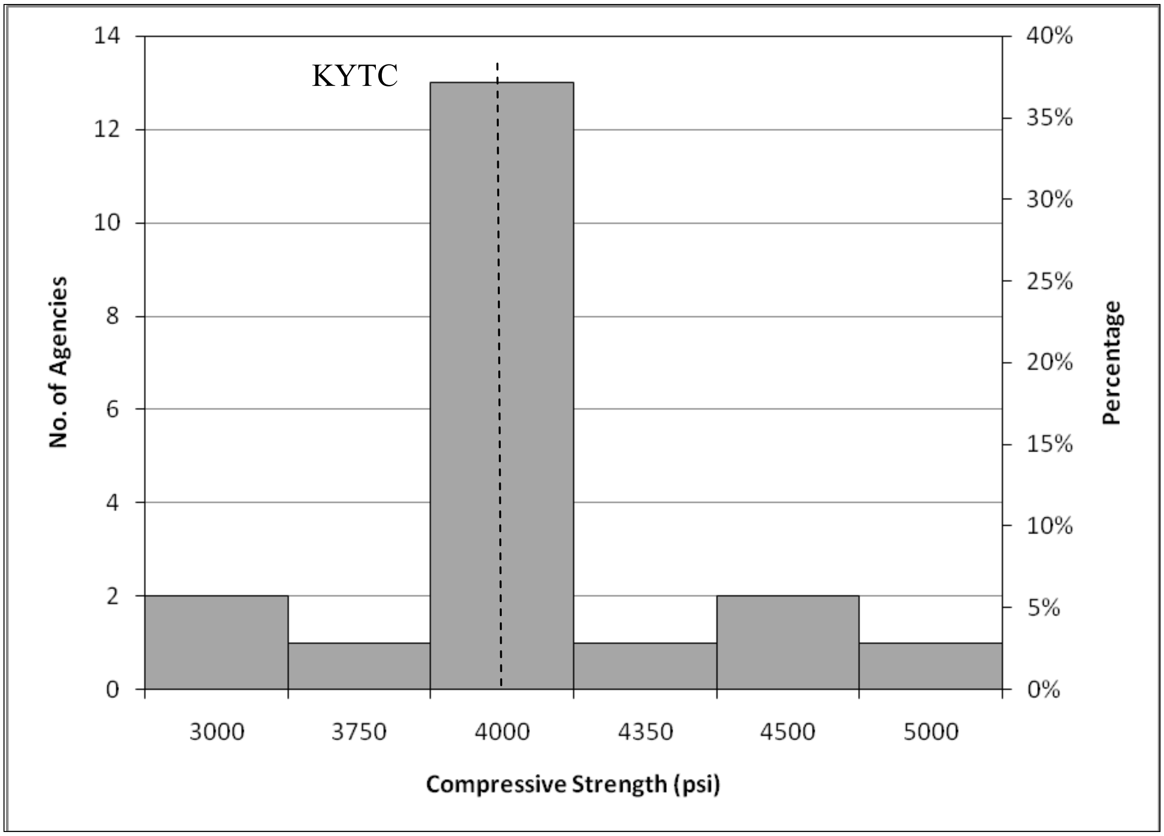


Figure 6.17: DOTs Structural PCC Compressive Strength Requirements as Compared to Kentucky (Total = 20)

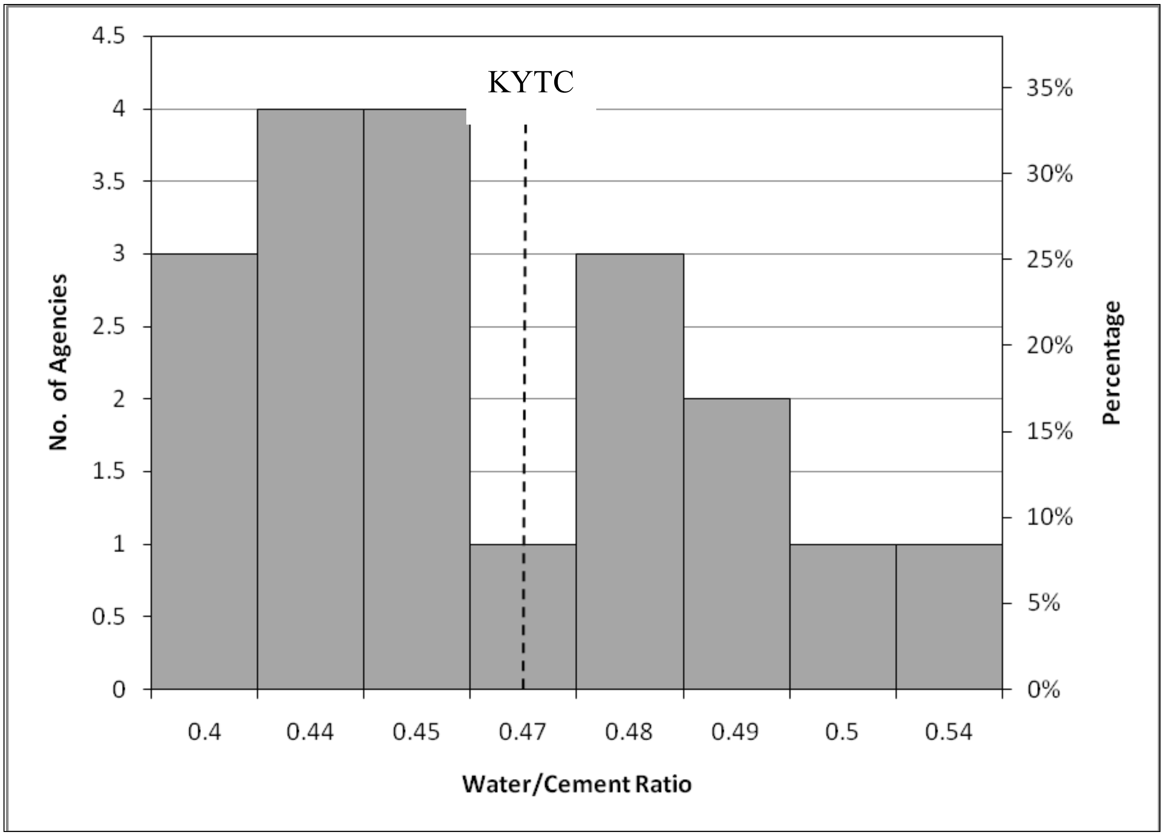


Figure 6.18: DOTs Structural PCC Water to Cement Ratio Requirements as Compared to Kentucky (Total = 19).

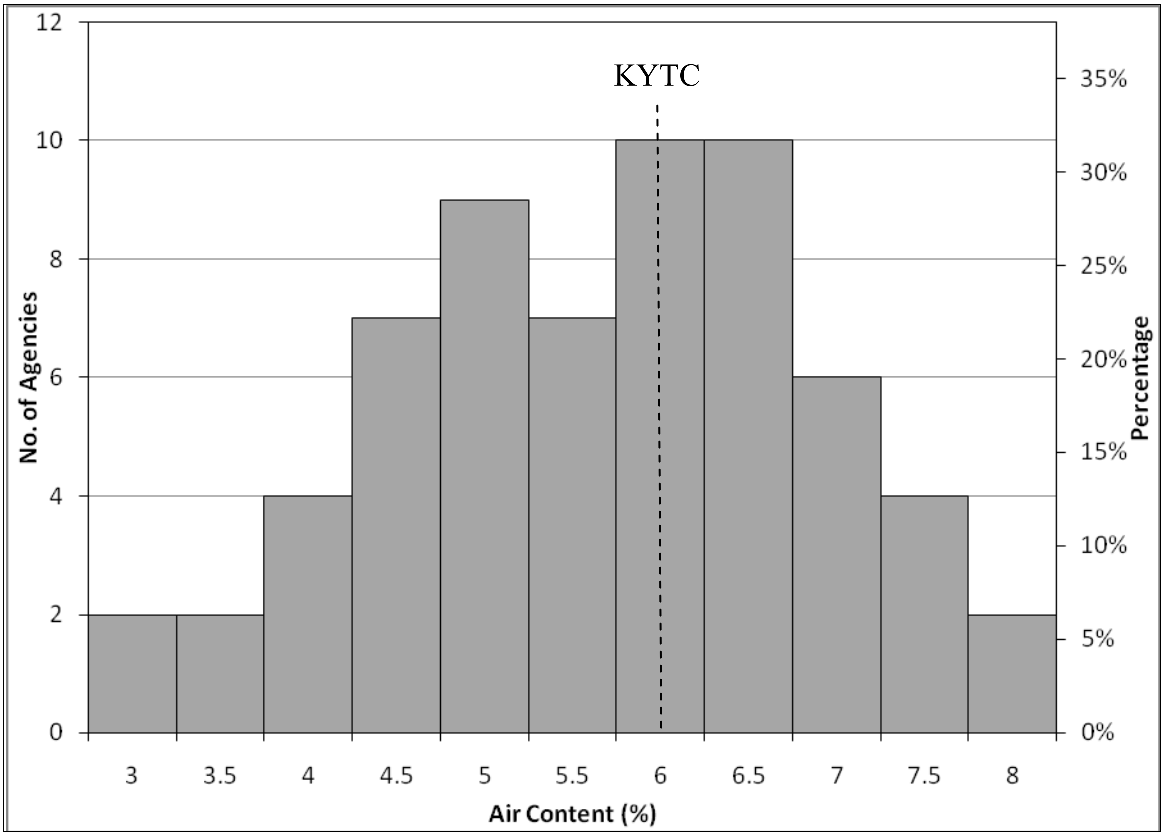


Figure 6.19: DOTs Structural PCC Air Content Requirements as Compared to Kentucky (Total = 19).

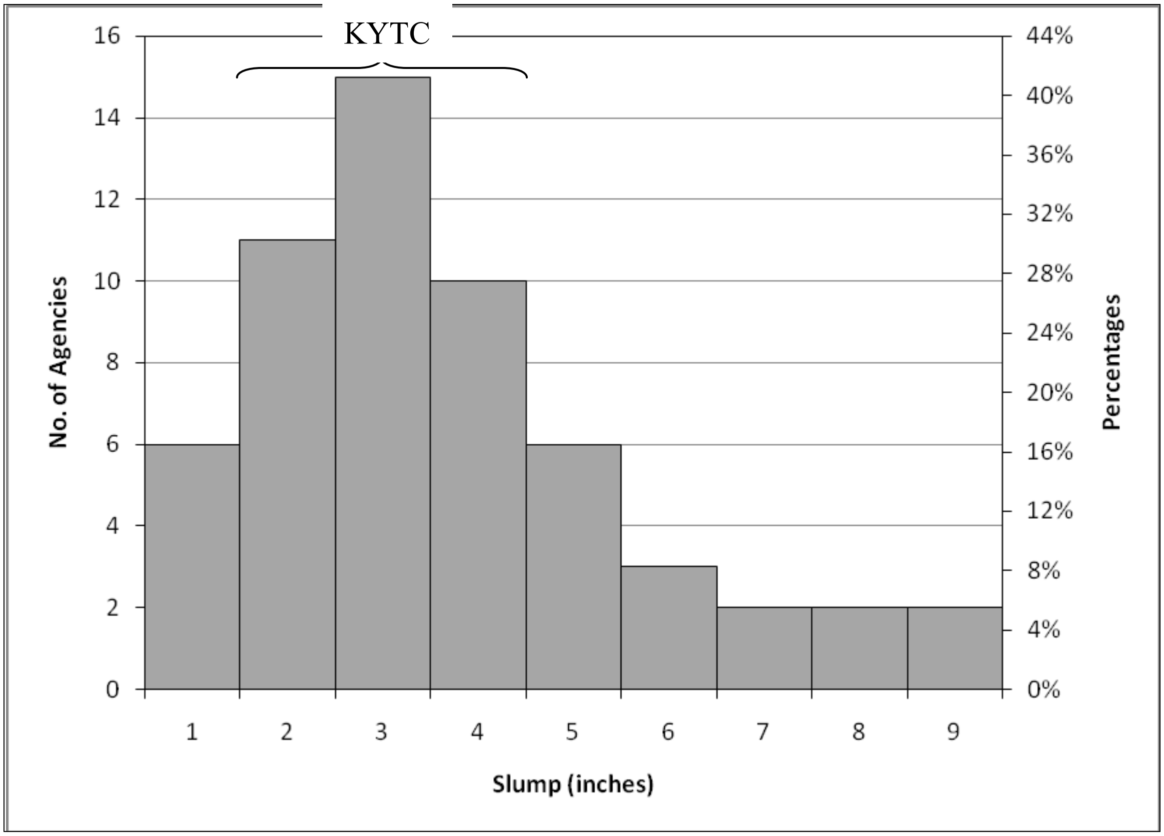


Figure 6.20: DOTs Structural PCC Slump Requirements as Compared to Kentucky (Total = 22).

6.2.4 Aggregates

The aggregates QC/QA survey had only eight responses. This was similar to the response rate for structural concrete. All eight agencies reported that the contractor was responsible for conducting the QC tests. Only one agency was reported to be responsible for evaluating the QC test result. One agency was responsible for initiating the corrective action, and seven reported that the contractor was responsible for both evaluation and initiating corrective action.

Six out of eight DOTs reported that the frequency of QC testing for aggregate was established by the agency. Five out of eight DOTs reported that the Quality assurance testing was done both in-house as well as by consulting firms. The agencies reported using AASHTO, ACI, and their own state certification programs. The frequency of DOT verification testing was about two DOT tests for every ten contractor tests.

The responses also indicated that the QA tests were used both for QC test verification and final pay adjustments. Seven of the agencies reported that independent assurance testing was done and conducted by the DOT. One agency indicated that independent assurance was not conducted by the agency.

The survey responses indicated that the following were the most popular aggregate properties for QC/QA testing:

1. Gradation;
2. Minus #200 sieve;
3. Compaction; and
4. Moisture Content.

The distribution of the properties used for QC and QA testing by various states can be seen in Figure 6.21.

The survey responses indicated that the quality measures most often used for the acceptance of aggregate base and subbase are average and range. By contrast, the NCHRP Synthesis 346 reported that the acceptance measure most often used is often a single value (Hughes, 2005). Some states use a more statistically based approach, which may include: standard deviation, tolerance, and percent within limits.

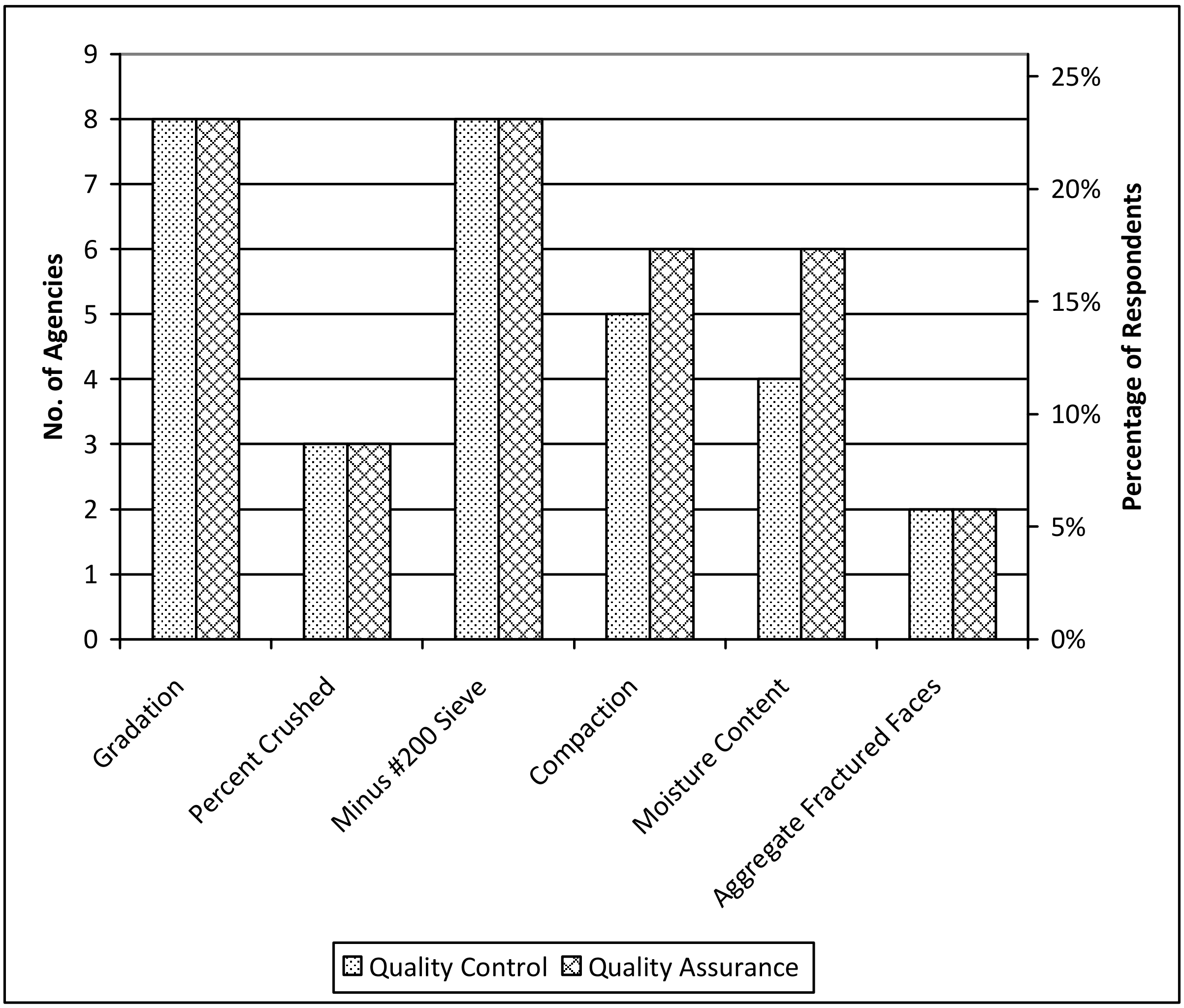


Figure 6.21: Aggregate Properties Tested for QC and QA (Total Responses=8)

The survey results indicated that four out of the eight respondents did have a central database and four did not. Of the agencies that do have a central database, only one stated that both agency and contractor personnel are required to be familiar with the database.

6.2.5 Soil and Embankment

The six responses for the soil and embankment survey indicated that the contractor is responsible for conducting all the QC tests. Three of the states indicated that both the contractor and the agency are responsible for evaluating the QC tests. Only one agency indicated that only the agency is responsible for initiating corrective action, one agency indicated that both contractor and agency are responsible for initiating corrective action. Three of agencies indicated that the contractor is responsible for both evaluating the QC tests and initiating corrective action if necessary.

The survey responses indicate that the testing frequency is established solely the DOT. Four of the agencies indicated that QA testing is conducted both in-house and by consulting firms. The agencies that use outside testing firms use AASHTO and their own state certification to determine the technician qualifications. The approximate average percentage of DOT verification was around two DOT tests for every ten contractor tests. Two of the agencies indicated that QA tests are used for QC test verification, while two agencies indicated that QA tests are used for final pay adjustments. Independent assurance testing was reported to be done by five of the six agencies.

The most popular soil and embankment properties tested for QC/QA are:

1. Moisture Content and
2. Compaction

These properties were also reported to be popular according to the NCHRP Synthesis 346. The distribution of these properties used for QC/QA testing can be seen in Figure 6.22.

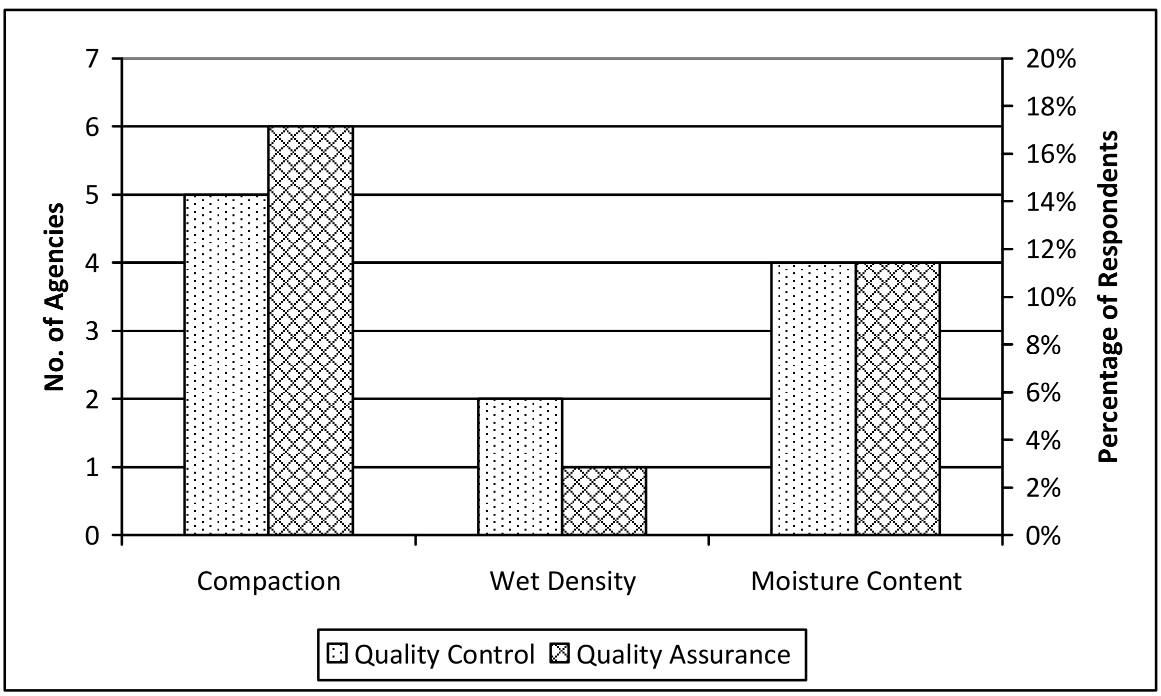


Figure 6.22: Soil and Embankment Properties Tested for QC and QA (Total Responses=6)

The survey responses indicated that two agencies use range and two use tolerance as the measure of quality for acceptance. The NCHRP synthesis 346 reported that an individual value is the most used measure of quality for acceptance of soil and embankments (Hughes, 2005). In terms of a central database, two agencies reported that they do have central databases, while three reported that they did not. One of the two states that do have a central database reported that both agency and contractor personnel are required to be familiar with the database. The two agencies that do have a database reported having a standard protocol. One agency reported that the protocol is being followed well, while the other state reported that it was being poorly followed. None of the agencies that responded reported using pay incentives and disincentives to adjust the contractor payment for soil and embankments.

Figures 6.23-6.24 depict comparisons between the soil and embankment concrete specifications in Kentucky versus 15 to 27 other DOTs who were randomly selected. It appears that Kentucky requirements in this are in the mid to lower ranges.

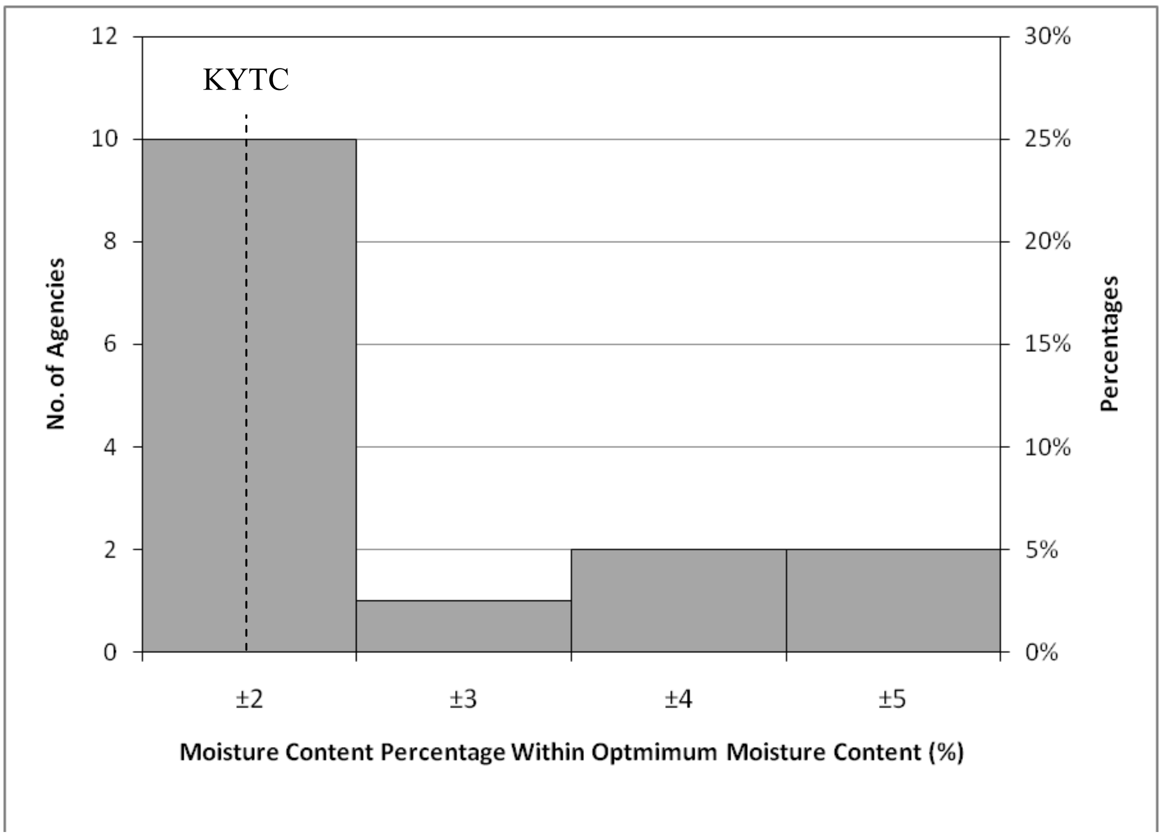


Figure 6.23: DOTs Embankments Moisture Content Acceptance Limits as Compared to Kentucky (Total = 15).

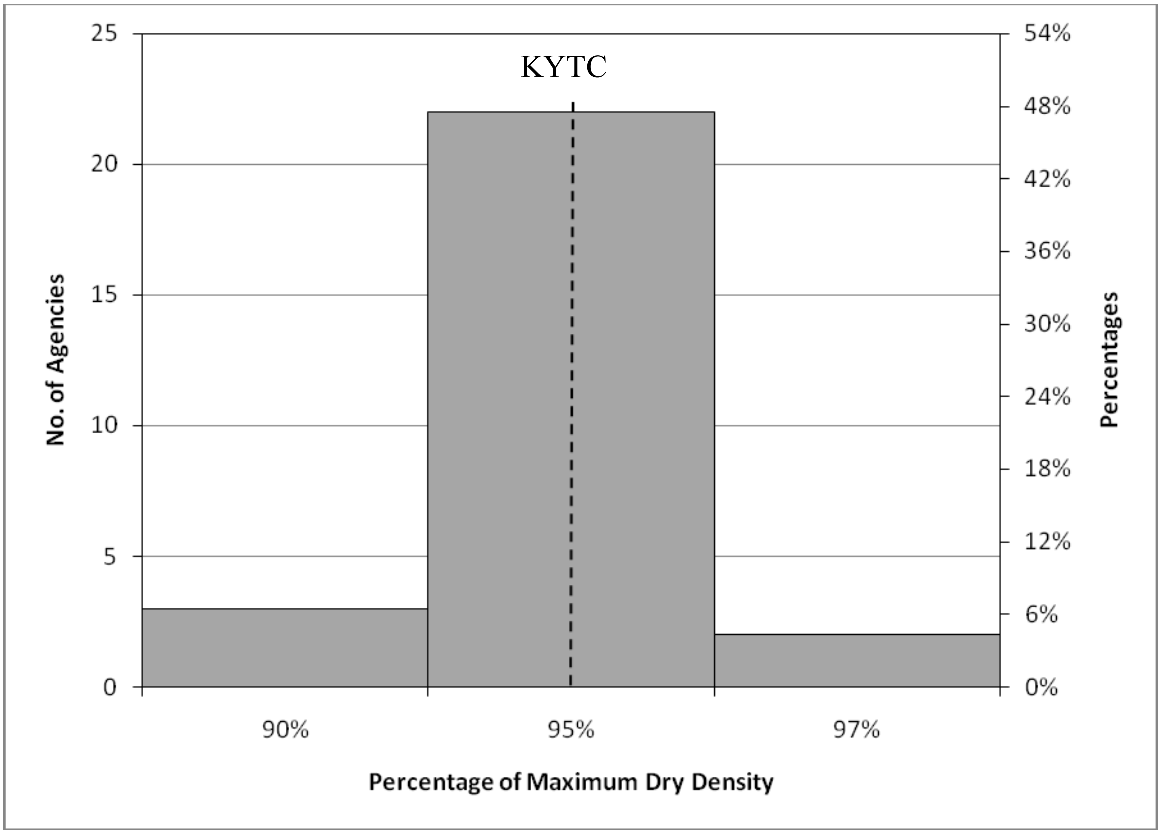


Figure 6.24: DOTs Soil and Embankments Compaction Acceptance Limits as Compared to Kentucky (Total = 27).

6.3 Overall QC/QA Experience

The survey in this section focused on the general level of satisfaction that state DOTs hold about their current QC/QA programs. Questions were asked about the impact of their QC/QA programs on project quality, cost, schedule, and legal disputes. The survey also sought information about the approximate percentage of contractors who receive 100 percent pay, as well as those who receive a bonus or a penalty.

6.3.1 Hot Mix Asphalt

The agencies reported an overall positive impression of quality as a result of their QC/QA HMA specifications. While there seems to be a concern that QC/QA may be making the final product more expensive. Table 6.9 presents a summary of findings.

Table 6.9: Summary Impacts of HMA QC/QA Programs

Project Aspect	Very Negative	Negative	No effect	Positive	Very Positive
Quality	0 (0 %)	0 (0 %)	2 (8 %)	13 (54 %)	9 (38 %)
Overall Cost	0 (0 %)	5 (21 %)	12 (50 %)	6 (25 %)	1 (4 %)
Schedule	0 (0 %)	2 (8 %)	16 (66 %)	4 (18 %)	2 (8 %)
Legal Disputes	0 (0 %)	2 (8 %)	12 (50 %)	8 (33 %)	1 (4 %)

As depicted in Figure 6.25, the agencies were very satisfies with their HMA QC/QA specifications. The state DOTs who responded were either satisfied or very satisfied with the quality of their HMA finished product.

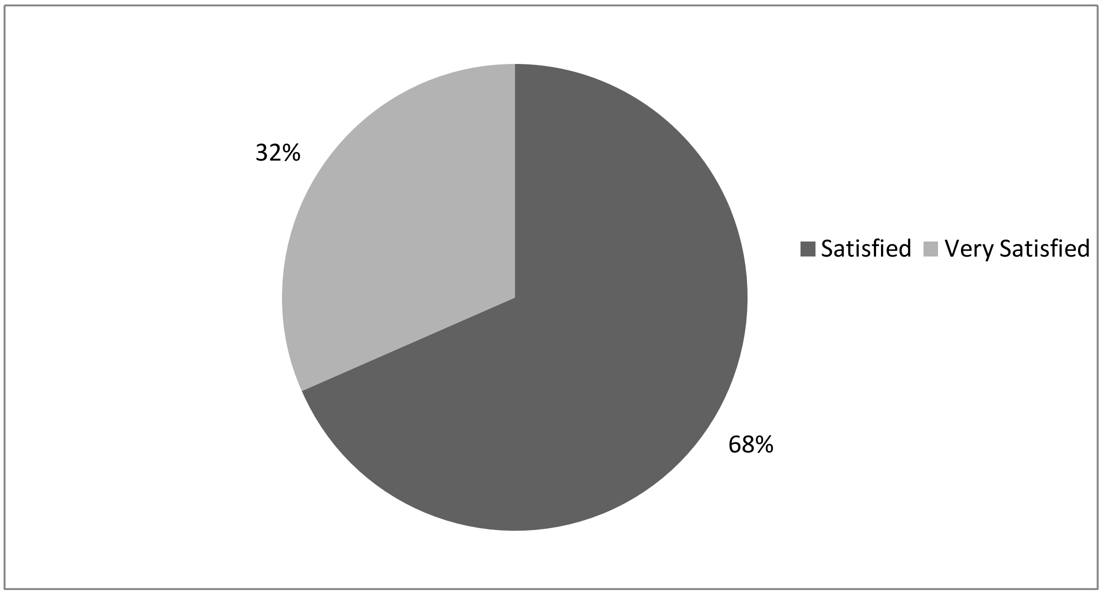


Figure 6.25: State DOT Degree of Satisfaction with HMA Quality

One might think that a high level of satisfaction with HMA quality should automatically correspond to 100 percent pay or bonus pay on most HMA projects. However, this may not be always the case. Figure 6.26 depicts the distribution of pay factors among the various states who responded to the survey. This figure shows that the pay factors do vary across a wide range, and there does not seem to be a bias in the system. The highlighted points were reported by the KYTC.

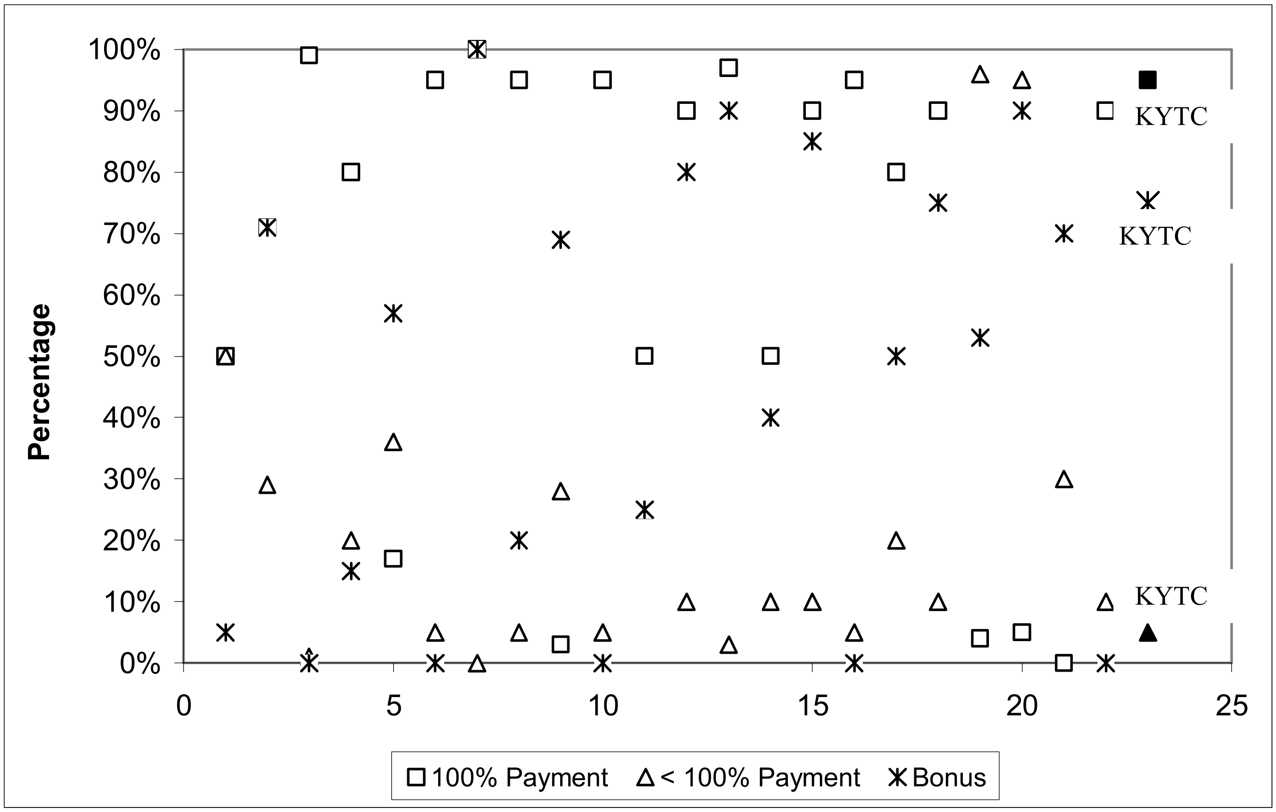


Figure 6.26: Distribution of Pay Percentages for HMA Projects

Eleven of the agencies who participated in the survey reported that they have experienced contractor submitting fraudulent QC data to satisfy the specification requirements. The actions that were taken by the agency or the contractor were suspension of the certification of the guilty technician for periods ranging from months to years, de-certification of the technicians, termination of technician's employment, banning the contractor from bidding on government projects, prosecution of contractor personnel, and the imposition of financial penalties

6.3.2 Portland Cement Concrete Pavement

The agencies reported an overall positive impression of quality as a result of their QC/QA PCCP specifications. Table 6.10 presents a summary of findings.

Table 6.10: Summary Impacts of PCCP QC/QA Programs

Project Aspect	Very Negative	Negative	No effect	Positive	Very Positive
Quality	0 (0%)	0 (0%)	0 (0%)	7 (70%)	3 (30%)
Overall Cost	0 (0%)	0 (0%)	3 (30%)	6 (60%)	1 (10%)
Schedule	0 (0%)	0 (0%)	7 (70%)	3 (30%)	0 (0%)
Legal Disputes	0 (0%)	1 (10%)	5 (50%)	4 (40%)	0 (0%)

As depicted in Figure 6.27, the agencies were mostly satisfied with their PCCP HMA QC/QA specifications.

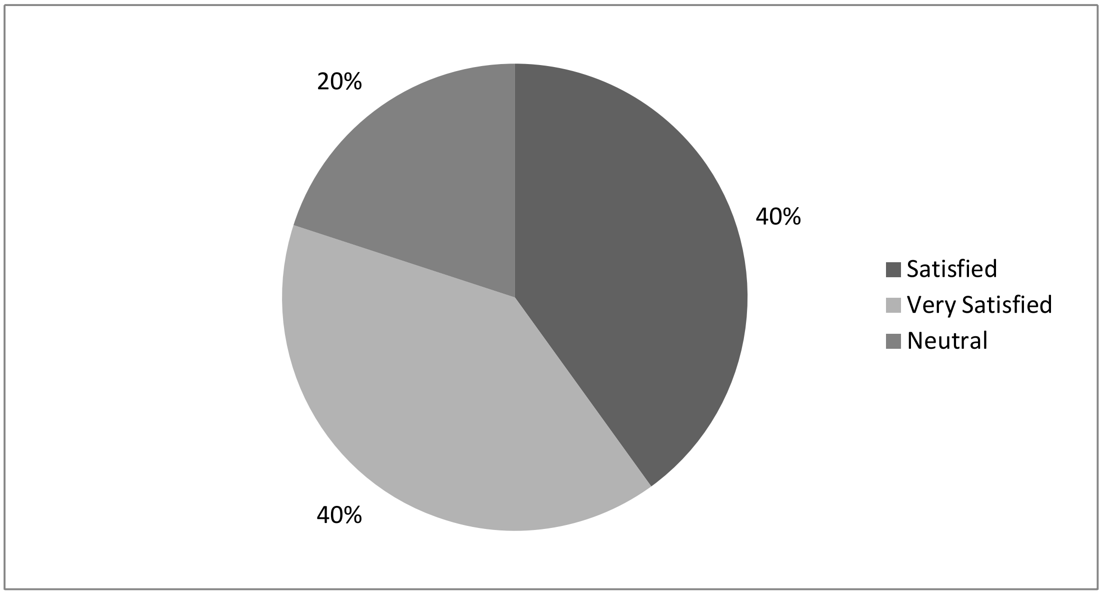


Figure 6.27: State DOT Degree of Satisfaction with PCCP Quality

Figure 6.28 depicts the distribution of pay percentages among the various states who responded to the survey. This figure shows that the pay factors do vary across a wide range, and there does not seem to be a bias in the system. KYTC did not report the distribution of pay percentages for PCCP projects.

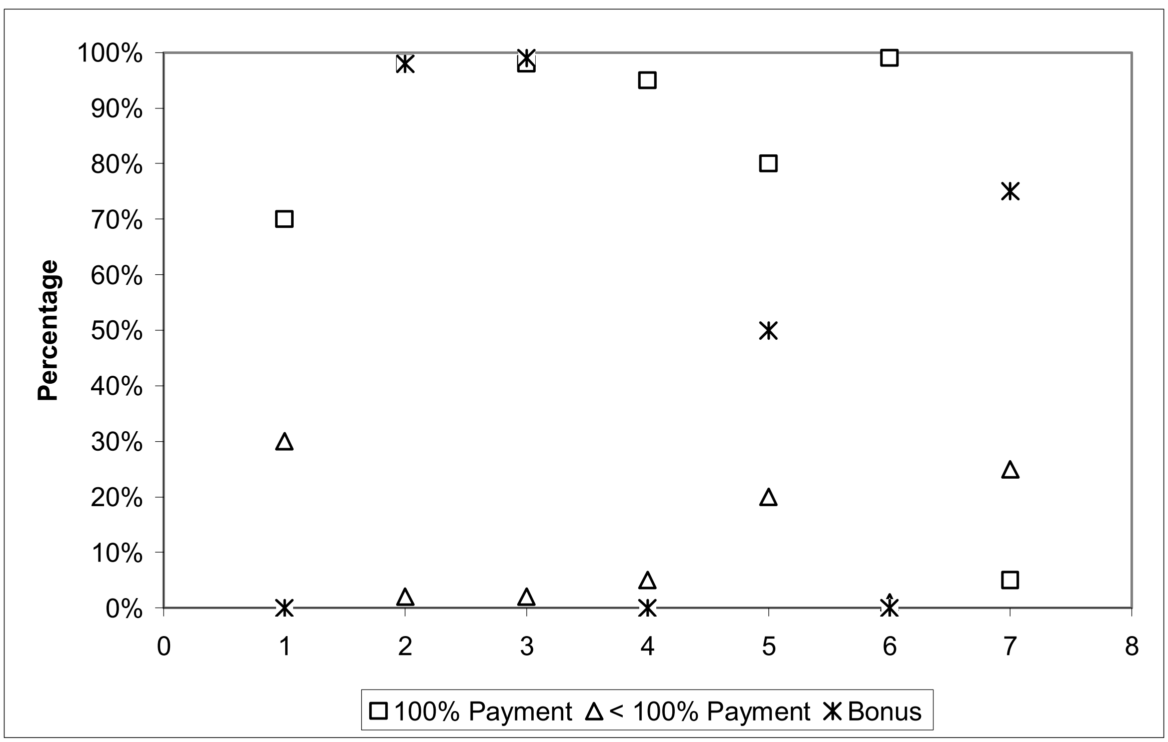


Figure 6.28: Distribution of Pay Percentages for PCCP Projects

Only one of the agencies reported having experienced contractor personnel submitting fraudulent QC data to satisfy the specification requirements. Another agency that responded also stated that "we need to figure out how to stop the lying, cheating and stealing from the Department. It is not widespread, but it is happening." Although the submittal of fraudulent QC data does not appear to be rampant with PCCP, it is becoming an issue to the agencies and it is undermining the trust between the two parties.

6.3.3 Structural Portland Cement Concrete

Similar to the PCCP, the agencies reported an overall positive impression of quality as a result of their QC/QA structural concrete specifications. Table 6.11 presents a summary of findings.

Table 6.11: Summary Impacts of SPCC QC/QA Programs

Project Aspect	Very Negative	Negative	No effect	Positive	Very Positive
Quality	0 (0%)	0 (0%)	0 (0%)	4 (80%)	1 (20%)
Overall Cost	0 (0%)	2 (40%)	2 (40%)	1 (20%)	0 (0%)
Schedule	0 (0%)	1 (20%)	3 (60%)	1 (20%)	0 (0%)
Legal Disputes	0 (0%)	0 (0%)	5 (100%)	0 (0%)	0 (0%)

The overall satisfaction results matched the data reported in Table 6.10.

6.3.4 Aggregates

The small number of responses for the aggregate survey revealed that the agencies reported an overall positive impression of quality as a result of their QC/QA aggregate specifications. Table 6.12 presents a summary of findings.

Table 6.12: Summary Impacts of Aggregates QC/QA Programs

Project Aspect	Very Negative	Negative	No effect	Positive	Very Positive
Quality	0 (0%)	0 (0%)	0 (0%)	5 (71%)	2 (29%)
Overall Cost	0 (0%)	1 (13%)	2 (29%)	2 (29%)	2 (29%)
Schedule	0 (0%)	0 (0%)	3 (42%)	2 (29%)	2 (29%)
Legal Disputes	0 (0%)	1 (13%)	2 (29%)	2 (29%)	2 (29%)

The responses for the degree of satisfaction on the quality of the aggregate ranged from dissatisfied to very satisfied. Three agencies were very satisfied, one was satisfied, one was neutral, and one was dissatisfied.

There responses to the aggregate survey indicated that the majority of payments were around 100 percent pay, and no contractor received any bonus pay on aggregate projects. Finally, the aggregate survey did not report receiving fraudulent data.

6.3.5 Soil and Embankment

The small number of responses for the soil and embankment survey revealed that the agencies reported an overall positive impression of quality as a result of their QC/QA soil and embankment. However, the survey reflected neutrality on cost, schedule, and legal issues, and some weak negatives on quality and cost. Table 6.13 presents a summary of findings.

Table 6.13: Summary Impacts of Soil and Embankment QC/QA Programs

Project Aspect	Very Negative	Negative	No effect	Positive	Very Positive
Quality	0 (0%)	1 (25%)	0 (0%)	3 (75%)	0 (0%)
Overall Cost	0 (0%)	1 (25%)	3 (75%)	0 (0%)	0 (0%)
Schedule	0 (0%)	0 (0%)	3 (75%)	0 (0%)	1 (25%)
Legal Disputes	0 (0%)	0 (0%)	3 (75%)	1 (25%)	0 (0%)

The agencies reported that they had no experience with fraudulent data on their soil and embankment projects.

Chapter 7 – Conclusions and Recommendations

The overall experience with the QC/QA specifications in Kentucky and around the nation seems to be very positive. Most state highway agencies reported that the quality of the construction has improved as a result of their QC/QA policies. However, the higher quality may be coming at a higher cost. However, it must be noted that without any hard numbers, and considering the confounding effects of inflation, the higher cost may have other contributing factors. On the other hand, if the contractor is expected to do more testing, the cost of the finished product will naturally increase. Statistical data analysis of selected Kentucky projects revealed that, generally, the contractor reported data and the KYTC verification data were similar. This adds more confidence to the KYTC QC/QA system. A comparison of KYTC specifications limits with other state highway agencies revealed that, generally, the acceptance limits are within the norm. However, some minor fine tuning may be warranted in some case, such as HMA air and density.

The following recommendations are made for improving the performance of Kentucky QC/QA specifications.

- The use of statistics in the QC/QA specifications and quality evaluation should be promoted and enhanced.

- The Cabinet should record all project data in a user friendly data base for future retrieval and performance tracking. Most State DOTs suffer from the fact that they are data-rich but information-poor.

- The specifications should better define the authority for acceptance/rejection when testing consultants are involved.

- The QC/QA should not be used as vehicle for downsizing the KYTC personal, particularly the construction inspection staff.

- The KYTC should strengthen its project inspection by adding more personnel and training.

- Verification testing must be truly random and independent from the contractor equipment and personnel.

- The responsibilities for collection and handling of laboratory and field specimens must be better defined. All specimens must be better safeguarded and their chain of custody must be better defined and documented.

- Each project must be adequately monitored by a Quality Manager who works for the contractor.

- The KYTC should evaluate the effectiveness of its QC/QA training, and explore the option of accepting national certification programs for technicians.

- The KYTC districts should interpret and implement QC/QA specifications uniformly across the state.

- Given the rising cost of asphalt binder, requiring a binder content test is suggested

- Most states require 93%-94% solid density on HMA projects. Kentucky requires 92%, and it might need to be slightly modified. Similarly, the HMA air voids requirement in most sates is around 3%. Given the good quality of aggregates in Kentucky HMA, it might be a good idea to change the HMA air void requirement from 4% to 3%.

- Requiring portland cement concrete unit weight test is suggested.

- KYTC should move toward more non-destructive, non-invasive, real-time quality testing (similar to the current paint striping specifications).

- Some bonus pay schedules may need to be adjusted. For example, asphalt smoothness bonus may need to be conditional upon satisfactory density.

- Better partnering and sharing of the QC/QA responsibilities, including but not limited to bonus/penalties, between the contractor and its material suppliers can only enhance the focus on quality.

APPENDIX – A

Questionnaire for Resident Engineers

Name ________________________________
Project ________________________________
Date ________________________________

BACKGROUND

1. Do you have any broad introductory comments regarding QC/QA in Kentucky?

2. What specific projects are we going to discuss today?

3. Which materials (e.g. asphalt, concrete, soil, etc.) on the project are subject to QC/QA specifications?

4. What do you think about the adequacy of QC/QA personnel?
    a. Adequacy of DOT QA personnel?

    b. Adequacy of contractor QC personnel?

5. What do you think about the adequacy of verification?
    a. Adequacy of inspectors?

    b. Adequacy of enforcement powers (e.g. shut down powers, stop payments, etc.)?

    c. Any potential conflicts between parties (e.g. DOT vs. contractor, DOT vs. DOT)?

QC/QA PROCEDURES

6. Are the testing protocols being followed correctly?

7. Do you feel the right things are being tested to make sure that a quality finished product is produced?
    a. If not, what should be tested?

8. Do you feel that the QC/QA practices are applied uniformly across various projects in KY?
    a. If not, what are those changes?

    b. Have the changes helped?

9. What can be done in order to improve the accuracy of various measurements?

10. Do you think testing is done at the right frequency?

11. Do you feel current pay adjustments factors are fair?

TRAINING

12. Are the KYTC staff adequately trained to do their QA job effectively?
    a. What types of training would you recommend?

13. Are the Contractor staff adequately trained to do their QC job effectively?
    a. What types of training would you recommend?

14. Are there enough Quality Managers to oversee projects?

QC/QA SUBCONTRACTING

15. What is the extent of QC/QA subcontracting?

16. How are the QC/QA subcontractors performing?

17. Are there any possible conflicts of interest?

LESSONS LEARNED

18. Contractor lessons learned through past projects?

19. DOT lessons learned through past projects?

20. Were you involved on highway construction projects before KY QC/QA was implemented?
    a. If yes, do you think QC/QA is contributing to a better quality finished product?

21. What would you like to see changed in the use of QC/QA on your projects?
    a. Any changes in the specification language?

    b. Any changes in the specification enforcement?

APPENDIX - B

Meeting Minutes
12/8/06
Interview 1

Project:
I-75 Widening
From Heekin Pike underpass North to 0.8 miles south of KY 36
Grant Co.
CID #06-1257

QC on project:
Contractor:
Asphalt
(QC Manager for Contractor (Eaton): Allan Hamilton)

Subs:
Embankment subgrade
Aggregate
Concrete

Suggestions:
More time on nuclear density machine training

Finds the grade and drain level 2 training more effective

Stated that QC managers are the key responsibility for the quality of the project even if it passes QC specs

Bonus Issue:
Sees no problem with incentives if their going above project goals

Agrees bonuses are producing an efficient product

QC Paperwork:
Paperwork for QC is supposed to submit weekly

MEETING SUBJECT: Interview 2 Regarding QC/QA: Evaluation of Effectiveness Research Study			
Meeting Information			
MEETING DATE:	**January 25, 2007**	LOCATION:	**Frankfort, KY**
PREPARED BY:	**Jason Enlow**	MEETING TIME:	**8:00 AM**

↓ Add or delete addressees as necessary

DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Attendee 1	Kentucky Transportation Cabinet		
Attendee 2	Kentucky Transportation Cabinet		
Enlow, Jason	University of Kentucky		
Attendee 3	Kentucky Transportation Cabinet		
Mahboub, Kamyar	University of Kentucky		

MEETING PURPOSE

To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	REQUIRED DATE
1.00	**Introduction**	
1.01	Meeting attendees introduced themselves	N/A
2.00	**Background Comments (Attendees)**	
2.01	Inspectors aren't doing enough or proper testing. This may be because they are not properly trained, or they are new at QC/QA. There is not enough properly trained DOT staff that has experience with various QC/QA tests and protocols. The DOT staff that does have the proper training sometimes get disillusioned about the QC/QA process when they see all kinds of potential for abuse.	N/A
2.02	The question remains: should we base pay on QC or QA results? State tells where to do the cores for unit weight and density. This should be random. The specimen chain of custody needs to be better defined.	N/A
2.03	Regarding embankment, contractors have to do density tests; state workers are sometimes not there to verify the quality.	N/A
2.04	Perhaps the DOT should have its own gages for various field measurements, as opposed to the current practice of deferring to the contractor's gages.	N/A
2.05	State has cut back on nuclear density gauges, this has resulted in a potential for abuse by the contractor who gages are used for both QC and QA.	N/A
2.06	Perhaps we need to look into the option of using other gages which requires less training and easier to use (non-nuclear gages).	N/A
2.07	Historically projects had only one component defined as QC/QA. However, in recent years there are more than one item (i.e. asphalt, embankment, etc.).	N/A
2.08	Sometimes QC is being done without adequate QA on the project.	N/A
2.09	Sometimes the contractor has advance knowledge of the locations for the QA cores. This opens room for potential abuse.	N/A
2.10	QC/QA is still a learning process.	N/A

ITEM No.	DISCUSSIONS	REQUIRED DATE
2.11	On embankment projects, the contractor may need to do 2-3 times the testing on embankment that there doing now. Maybe testing should be based per lift?	N/A
2.12	The DOT inspection staff needs the support of the DOT administration if and when they do shut down the job for cause. The experience of not receiving the support from the DOT administration can have a disillusioning effect on the inspection staff.	N/A
2.13	Contractors are getting in the habit of getting extensions due to leniency from the state.	N/A
2.14	It seems that the QC/QA has contributed to a better finished product when in comes to asphalt and concrete.	N/A
2.15	Plant operators have become more aware of how to produce a better product since the implementation of QC/QA. (ex. asphalt plants used to be overseen by DOTs)	N/A
2.16	The quality of constructed embankments seems to be in doubt. The QC/QA protocols seem to be inadequate.	N/A
2.17	Most districts have only one or two nuclear density gages now (this is insufficient).	N/A
2.18	Perhaps we need to look into third party inspection quality and effectiveness.	N/A
2.19	On earthwork projects, contractor testing crew often oversee several jobs simultaneously. This may not be conducive to a good quality construction. Formal partnering might be a good idea to sharing of bonuses and penalties (i.e. contractor and material producer).	N/A
2.20	It's about time to take out the leniencies left in the QC/QA for the implantation transition period, and start being tougher on contractors. The transitionary period has long passed.	N/A
2.21	It is worth checking into getting the attention of the contractor by linking the regular bi-weekly pay to QC/QA performance on the job.	N/A
3.00	**General Actions List (ALL)**	
3.01	Note: 1997 QC/QA started on asphalt	
3.02	Full QC/QA job coming up in Somerset	

ITEM No.	DISCUSSIONS	REQUIRED DATE
3.03	Job in Pulaski Co.	
3.04	Job in Jackson Co.	

MEETING SUBJECT: Interview 3 Regarding QC/QA: Evaluation of Effectiveness Research Study			
		MEETING NO.	
MEETING DATE:	**February 13, 2007**	LOCATION:	**Covington, KY**
PREPARED BY:	**Jason Enlow**	ISSUE DATE:	

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DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Attendee 1	Kentucky Transportation Cabinet		
Enlow, Jason	University of Kentucky		
Goodrum, Paul	University of Kentucky		
Mahboub, Kamyar	University of Kentucky		

MEETING PURPOSE
To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	REQUIRED DATE
1.00	**Introduction**	
1.01	Meeting attendees introduced themselves	N/A
2.00	**Background Comments (Attendees)**	
2.01	General Contractor and Testing Lab Subcontractor Behavior: Companies involved in construction are looking to get paid and get out. There seems to be a detached attitude on the part of the contractor. Various pieces of the projects need to better fit together.	N/A
2.02	Regarding DOT personnel: there are not enough personnel to stay on top of QC/QA, interviewee thinks that one effect of QC/QA has been to cutback KTC staff. He expressed concern that there are currently not enough KTC inspectors to keep with the contractor QC activities. He also indicated that there was a concern that contractors would not have enough QC/QA personnel when the contractor QC/QA program first started, but these concerns have subsided, since more and more contractors are using subcontractors to meet their QC/QA obligations.	N/A
2.03	Regarding the enforcement powers: if a QC manager's certification is removed, the job cannot proceed because QC plan would be invalid.	N/A
2.04	Failing data sometimes are only reported by the contractor when the KYTC inspector is present at the jobsite.	N/A
2.05	KYTC has been using contractor QC/QA on Asphalt work since 2002. His office has been using QC/QA on concrete work with US-27 over the past year. US-27 is currently 75% complete. Rob Franksman is the project's resident engineer. QC/QA is reportedly going very well on the project. He indicated that contractors tend to take a greater ownership with QC/QA when pavement is involved, which may explain why this project is going so well.	
3.00	**QC/QA Procedures (Attendees)**	
3.01	He would like to see a unit weight test for concrete, not currently required.	N/A
3.01b	He indicated that contractors are subcontracting out their QC/QA obligations extensively.	

ITEM No.	DISCUSSIONS	REQUIRED DATE
3.01c	His main concern with the QC/QA subcontractors is that they will do only the minimum possible. Therefore, the notes have to be detailed, and you have to be sure that they are aware of the any changes to the notes compared to previous projects.	
3.02	He thinks if the state is applying the QC/QA non-uniformly across the state, this may be part of the learning process.	N/A
3.03	State is only requiring asphalt content records from plant, which may not always be sufficient. Currently, KYTC, doesn't require an extraction test. Adding the extraction might be a good idea.	N/A
3.03	He finds errors in the QC spreadsheet from time to time.	N/A
3.04	He feels QC/QA is generally applied consistently across the state, but he also indicated that QC/QA procedures differ from project to project. The QC/QA procedures are using addressed in a project's special notes. Eventually, he hopes that contractor QC/QA procedures will be specified in standard specifications.	N/A
3.05	He would like to see a lot more design-build style approach to more jobs on highway projects. He commented that design-build has worked well in his district. A past design-build project in his district involving KY-9 was featured in Construction Digest (Sept. 27, 1999 edition) in an article titled, "A Wall-to-Wall Success.).	N/A
3.06	He thinks we should change incentives schedule to get more performance for the money.	N/A
3.07	The randomness and independence of the KYTC testing must be preserved.	N/A
3.08	He would like to see some non-destructive methods for testing that would give a better description of the quality of the finished product.	N/A
3.09	Typical resurfacing jobs only have approximately 4,000 to 6,000 tons per job; this will only provide 1 to 1.5 testing lots. Lots should be flexible.	N/A
3.10	He felt that the testing frequencies are pretty solid, but when data points shift toward samples being outside of specifications repeatedly, perhaps the job should be shut down in order to fix the problem before moving forward.	N/A

ITEM No.	DISCUSSIONS	REQUIRED DATE
3.11	Pay factors are influencing how contractors are bidding jobs. Some contractors are bidding low in anticipation of making up for their low bids with maximum bonuses on their pay factors. If they only receive 100% on the pay factors, they are being paid below their costs.	N/A
3.12	He indicated that he is not too concerned with the accuracy of the tests on the projects, but he is more concerned with the accuracy of the reporting. Sometimes, there are pressures to not report accurate numbers, but these pressures also occurred before contractor QC/QA.	
3.13	He also felt that it would help if the QA testing occurred in house. Currently, QA testing occurs at the closest lab to the jobsite, which is often the contractor's offices. He felt it would help with the accuracy of the some of the reporting if the QA testing was conducted at the closest District Lab.	
3.14	Regarding potential conflicts with the use of QC/QA subcontractors, sometimes, there may be instances when the QC/QA subcontractor may feel pressure to report inaccurate numbers. He indicated that this was only his opinion. However, the pressure of loosing future work on behalf of QC/QA subcontractors is not that great, since there are not a lot of certified testing labs; the competition for QC/QA labs is not great.	
4.00	**Training (Attendees)**	
4.01	He felt that what is being offered in the training classes are good, but there are not many well experienced personnel working with QC/QA in the DOT. He expressed concerns that with the state's retirement window coming up (2008) may leave a bigger void in experienced personnel. He also expressed that he was concerned with the availability of trained and experienced QC personnel on the contractor's side.	N/A
4.02	State can modify QC plan during the job if it sees any problems with QC managers.	N/A

5.00	**QC/QA Subcontracting (Attendees)**	
5.01	Not as concerned about subcontractor inspecting. Could see improvement in making subcontractors aware of changes in the KYTC Specifications and Special Notes. There have been cases where subcontractors have claimed they were unaware of changes in the KYTC Specifications and Special Notes.	N/A
5.02	Can see a potential for conflict of interest when the testing lab hopes to get future business from the contractor. Anther example is when the testing lab is a subsidiary of the contractor.	N/A
6.00	**Lessons Learned (Attendees)**	
6.01	Regarding Independent Assurance: Feels that KYTC can do it much better and cheaper.	N/A
6.02	Feels bigger contractors may have some partnerships with smaller contractors in performing QC/QA, once some bigger contractors have established a good QC system.	N/A
6.03	The impact of QC/QA on performance is unclear, due to the lack of long-term performance data.	N/A
6.04	He thinks that the contractors will try to do the minimum they can to get by with as they get more and more experienced with the QC/QA and all of its nuances. This may reduce the quality of the finished product.	N/A
6.05	Biggest complaint is the incentive schedules. Contractors come into the job expecting it. The state needs non-destructive test methods to verify the contractor numbers.	N/A
6.06	Sees how incentives are necessary but product needs to be tested entirely, like with striping testing (entire striping job is tested for reflectivity). He noted that the striping incentives do work very well, because IT CAN BE INDEPENDENTLY VERIFIED.	N/A
6.07	Agrees strongly with roadway warranties, feels it is a good way to get contractor's attention.	N/A
6.08	He thinks that many of the contractors will start to do all of their testing in-house. He mentioned a company that has very qualified asphalt QC staff, so they will probably start doing QC themselves.	

6.09	When contractor QC/QA was first implemented, contractors tried very hard to develop their processes. This improved QC/QA in the short term, but he has a concern that in the long-term, QC-QA may go back to the previous “Norm”.	
7.00	**General Actions List (ALL)**	
7.02	U.S. 27 Highway job has the Special Note for concrete. Contacts: Rob Frankson, Hinkle Contracting. Contact Rob for an interview	
7.03	Eaton Asphalt: has own in house quality control. Contact them for information.	
7.04	KY 9 Design-Build job came in well under budget and ahead of schedule. Gather information on that project.	

MEETING SUBJECT: Interview 4 Regarding QC/QA: Evaluation of Effectiveness Research Study, Primarily Focusing on Asphalt.			
MEETING DATE:	**February 20, 2007**	LOCATION:	**Phone Interview**
PREPARED BY:	**Jason Enlow**	ISSUE DATE:	

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DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Mr. Jason Enlow	University of Kentucky		
Dr. Paul Goodrum	University of Kentucky		
Mr. Nicholas Hendrix	University of Kentucky		
Dr. Kamyar Mahboub	University of Kentucky		
Attendee 1	Kentucky Transportation Cabinet		

MEETING PURPOSE
To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	PROJECT DATES
	Introduction	
	Meeting attendees introduced themselves	N/A
	Background Comments (Attendees)	
1.	Do you have any broad introductory comments regarding QC/QA in Kentucky? Answer: Asphalt QC/QA has been in place for that past 10 years, and to some degree has improved the quality of the finished product the state has been getting. Although, one must remember that it is hard to separate out the influences of Superpave, new specifications, and QC/QA practices, and their impacts on quality. There are still some issues with the FHWA. FHWA concerns are with the verification procedures. FHWA points to the compliance regulations: 23CFR637. This regulation permits using the contractor data for acceptance and pay purposes, provided that there are adequate and independent verification processes in place. The state doesn't take a totally independent sample; they take a sample out of the same truck as the contractor does. Although it is not a split sample. The state doesn't perform Percent within Limits (PWL) or statistical t-tests tests with asphalt data.	N/A
2.	What specific projects are we going to discuss today? Answer: None specific, but the interview did focus on Asphalt QC/QA.	N/A
3.	Which materials (e.g. asphalt, concrete, soil, etc.) on the project are subject to QC/QA specifications? Answer: N/A	N/A
4.	What do you think about the adequacy of QC/QA personnel? Answer: The KYTC QC/QA inspection personnel are right at the threshold of being adequate. Any more frequent testing mandated, say by FHWA, would put more demand on an already stretched inspection crew.	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
5.	What do you think about the adequacy of verification? Answer: Sometimes a job is not up to par, but it isn't enough to shut the job down. Sometimes the department will penalize and only pay 90%. For instance if the contractor is constantly running a density that is low, the contractor will take a deduction in pay. They're willing to do this to avoid the project being shut down. Maybe a specification could be created for enforcement if the contractor is constantly running at the margins of specifications on a job. He felt that if a contractor is consistently receiving a 90% pay factor (meaning that they are below the expected quality standards) that the work should probably stop until the problem is fixed. After fixing the problem, the work can resume, and the contractor can receive 100% pay, and the KYTC can receive a better product in return.	N/A
	QC/QA Procedures (Attendees)	
6.	Are the testing protocols being followed correctly? Answer: In general, every district does things a little different. For example: the chain of custody of the cores is sometimes handled with some variability- some district inspectors retrieve cores as they are drilled, some let contractors drop cores off at the KYTC materials office. Asphalt QC/A specifications are in a better position to be followed; they are all in the KYTC Standard Specifications. As opposed to some other QC/QA items that are still operating based on Special Notes.	N/A
7.	Do you feel the right things are being tested to make sure that a quality finished product is produced? Answer: FHWA would like to require an extraction ignition test. He feels we are testing the right properties, he wishes that there were more in situ and non-destructive quality measurements - with direct links to performance - as opposed to lab and field tests that are indirectly related to performance.	N/A
8.	Do you feel that the QC/QA practices are applied uniformly across various projects in KY? Answer: Yes. Asphalt mix is in KYTC Standard Specifications. All other QC/QA specifications are in Special Notes on plans.	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
9.	What can be done in order to improve the accuracy of various measurements? Answer: Probably more pressure from QC Manager. There is some pressure to not report inaccurate results, more so on the contractor than the Cabinet.	N/A
10.	Do you think testing is done at the right frequency? Answer: Currently, testing is done every 1000 tons, but He would like to see testing done more frequently. However, current manpower restrictions won't permit this. At the same time, there must be enough flexibility available on smaller jobs.	N/A
11.	Do you feel current pay adjustments factors are fair? Answer: Contractors tend to lean on pay factors, and depend on them as part of the pay in the contract. Pay factors are probably a little lenient (example: percent of solids is 92% in Kentucky for 100% pay; while in most states it is probably 93-94%). Air voids are right around 4% and maybe should be lower given the good aggregates in Superpave mixes.	N/A
	Training (Attendees)	
12.	Are the KYTC staff adequately trained to do their QA job effectively? What types of training would you recommend? Answer: Anyone who does verification tests are being qualified through a good training program, whether they use the training and apply it to hard to measure.	N/A
13.	Are the Contractor staff adequately trained to do their QC job effectively? What types of training would you recommend? Answer: Feels training is adequate, they go to the same training programs that the KYTC staff attends. He thought it would be interesting to not just train contractor staff to do their own testing but to also do their own inspection.	N/A
14.	Are there enough Quality Managers to oversee projects? Answer: This is an issue at times. He would like to see more Quality Managers.	N/A
	QC/QA Subcontracting (Attendees)	

ITEM No.	DISCUSSIONS	PROJECT DATES
15.	What is the extent of QC/QA subcontracting? Answer: Most HMA producers do not use subcontractor testing labs, but use in house testing. On total QC/QA jobs, contractors have hired consultants to run QC/QA on their jobs. He felt that the state is leaning towards contractor QC/QA partly as a result of downsizing, which he notes is partly motivating other state transportation agencies to use contractor QC/QA..	N/A
16.	How are the QC/QA subcontractors performing? Answer: N/A	N/A
17.	Are there any possible conflicts of interest? Answer: N/A	N/A
	Lessons Learned (Attendees)	
18.	Contractor lessons learned through past projects? Answer: N/A	N/A
19.	DOT lessons learned through past projects? Answer: Because they are not at the plants all the time, state inspectors need to be very diligent while at asphalt plants doing inspection. The alternative would be to place a state inspector at the plant full time, which currently very difficult due to manpower shortages.	N/A
20.	Were you involved on highway construction projects before KY QC/QA was implemented? If yes, do you think QC/QA is contributing to a better quality finished product? Answer: Thinks we are getting a better product, but not sure if it is because of QC/QA or because of other changes that were implemented at the same time, like the switch to Superpave.	N/A
21.	What would you like to see changed in the use of QC/QA on your projects? Answer: N/A	N/A
	General Comments (Attendees)	
	Would like to see someone take a regular project and do a statistical comparison.	

ITEM No.	DISCUSSIONS	PROJECT DATES
	Sometimes QC managers don't complete their information sheets because they're not immediately available.	
	The concern is that administrators may want to use QC/QA as a way of cutting back KYTC personnel.	
	New program, Site Manager, for entering QC data should be up and going in the next month or so, old projects will stay in their current software. Site Manager should be a way for us to access archived QC/QA data.	
	In April FHWA representative Dennis Devorak is coming to the state to evaluate QC/QA (Audit).	
	He expressed interest in a tool that could be used by state engineers that can be easily used to determine how many QA tests they should run in order to have a large enough sample size for a valid F-test, or t-test.	
	Action Items	
	Contact for project data. These projects should include projects with 100% pay + bonus, and some projects with less than 100% pay.	
	Contact: Dennis Devorak for interview	

MEETING SUBJECT: Interview 5 Regarding QC/QA: Evaluation of Effectiveness Research Study, Primarily Focusing on Embankment.			
MEETING DATE:	**February 23, 2007**	LOCATION:	**Phone Interview**
PREPARED BY:	**Nicholas Hendrix**	ISSUE DATE:	

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DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Jason Enlow	University of Kentucky		
Paul Goodrum	University of Kentucky		
Nicholas Hendrix	University of Kentucky		
Kamyar Mahboub	University of Kentucky		
Attendee 1	Kentucky Transportation Dept.		

MEETING PURPOSE
To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	PROJECT DATES
	Introduction	
	Phone conference attendees introduced themselves	N/A
	Background Comments (Attendees)	
1.	Do you have any broad introductory comments regarding QC/QA in Kentucky? Answer: He has been involved in a couple of QC/QA embankment projects. The current note has been changed based upon lessons learned with the early projects.	N/A
2.	What specific projects are we going to discuss today? Answer: KY 555 in Washington, Nelson, and Anderson Counties. On this project, KYTC was under equipped with nuclear density gauges and used the contractor's gauge to verify previous tests taken with that same gauge. KY-555 was not the best project to use with the new QC/QA note, because most of the embankment excavation was rock. There was a lot of concern on behalf of the contractor with the cost of staffing a quality manager on the project, who was subcontractor. The cost of the quality manager was greater than anticipated.	N/A
3.	Which materials (e.g. asphalt, concrete, soil, etc.) on the project are subject to QC/QA specifications? Answer: Embankment and subgrade are his specialty areas.	N/A
4.	What do you think about the adequacy of QC/QA personnel? Answer: There are not enough QA personnel working for KYTC on embankment projects. The state is using its own consultants' inspectors on many embankment projects. Similarly, there are not enough QC personnel working for the contractor. Every contractor that has performed embankment QC/QA has used a subcontractor. There is no current in-house QC/QA work on behalf of the contractor. His experience has been that contractors have primarily been	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
5.	What do you think about the adequacy of verification? Answer: a. Projects are understaffed on the DOT side and he thinks they will continue to be understaffed. b. Depends on the contractor. Some contractors will put a great deal of pressure on the engineer to pass the inspection reports. This is something that has always existed even before QC/QA. c. Can be a problem with the "rent-a-tech" program. Some amendments have been made. If a consultant wins the bid to be the contractor's QC representative on a KYTC project, that consultant cannot work for the same contractor or any other in that DOT designated region (See General Comments). The overall experience of having testing consultants involved in the embankment projects has been positive.	N/A
	QC/QA Procedures (Attendees)	
6.	Are the testing protocols being followed correctly? Answer: Yes, the quality of QORE Co. testing has been solid for all projects. This may be due to their specialization (QORE as well as their production level testing (See General Comments)	N/A
7.	Do you feel the right things are being tested to make sure that a quality finished product is produced? Answer: Currently density, moisture content, and lift thickness are being tested. It would be good to know exactly what type of material is going into embankment (sand, clay- high plasticity, low plasticity, durable versus on-durable shale, etc.) as opposed to just "soil" or "rock." A periodic soil classification testing would be helpful. They are also currently doing a one-point proctor curve measure.	N/A
8.	Do you feel that the QC/QA practices are applied uniformly across various projects in KY? Answer: Not fully. KYTC should offer inspector classes where inspectors have to run nuclear density tests on soil, aggregate, and pavement before certified. Currently, the state uses the same QC/QA special note. A 100-page QC/QA standard note has been developed, but it has not been issued.	N/A
9.	What can be done in order to improve the accuracy of various measurements? Answer: Currently, tests are recorded on paper and placed in a folder that is kept in the Resident Engineer's office. Suggestion: to use the Site Manager for materials and record in an Excel spreadsheet that can incorporate exact location of test, target densities, target	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
	percent moisture, and actual readings.	
10.	Do you think testing is done at the right frequency? Answer: Current testing frequency is confusing. The frequency right now is low because it's focused on testing bridge abutments (1 test per foot of embankment placed). There should be a higher frequency of testing based on yards of material placed (quantity as opposed to testing per foot of elevation). Specifications should include new language to reflect this suggestion.	N/A
11.	Do you feel current pay adjustments factors are fair? Answer: Currently we are not using any pay adjustment factors for embankment and subgrade. The QC/QA activities are set up as a pay item. After the 2^{nd} phase of QC/QA implementation, however, these will no longer be a separate bid item.	N/A
	Training (Attendees)	
12.	Are the KYTC staff adequately trained to do their QA job effectively? What types of training would you recommend? Answer: KYTC staff are adequately trained. The addition of national training (for example NICET) would be good.	N/A
13.	Are the Contractor staff adequately trained to do their QC job effectively? What types of training would you recommend? Answer: Most of the personnel that the contractors are sending to training sessions are foremen or equipment operators on their way to becoming foremen. Most have the skills and education to understand and do well in the training. However, the 2-day training is not always enough. Sometimes, the experience of performing QC/QA in the field is also needed.	N/A
14.	Are there enough Quality Managers to oversee projects? Answer: No. The KYTC staff is spread very thin.	N/A
	QC/QA Subcontracting (Attendees)	
15.	What is the extent of QC/QA subcontracting? Answer: QC/QA subcontracting for embankment has been 100%. No prime contractors have performed their own testing to date.	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
16.	How are the QC/QA subcontractors performing? Answer: Very consistently. To date, the QORE Co. has been the only subcontractor for embankment projects.	N/A
17.	Are there any possible conflicts of interest? Answer: N/A	N/A
	Lessons Learned (Attendees)	
18.	Contractor lessons learned through past projects? Answer: The need to have their own personnel to perform QC tests. It is also important for the contractor to educate their foremen and equipment operators of the importance of quality and QC/QA testing.	N/A
19.	DOT lessons learned through past projects? Answer: The need to have more people (inspectors) on the job. There is a significant administrative barrier between KYTC inspectors and the "rent-a-techs" (RATs) because RAT's are not KYTC employees. KYTC personnel must input inspection data into the state's computer system for RAT's. The transportation cabinet hasn't conveyed the importance to DOT personnel of their job.	N/A
20.	Were you involved on highway construction projects before KY QC/QA was implemented? If yes, do you think QC/QA is contributing to a better quality finished product? Answer: Yes. There has been some improvement. The level of inspection on the QORE inspected projects is more consistent. Overall, pavement quality has improved in Kentucky, but he is not sure whether it's due to QC/QA or the Superpave approach.	N/A
21.	What would you like to see changed in the use of QC/QA on your projects? Answer: He is currently working a review of the entire geotechnical specification. Agrees with upcoming changes for chemically stabilized roadbeds (lime versus cement). That is broadening the range for cement stabilization, as well as focusing on the finished product quality instead of ingredients. See General Comments.	N/A
	General Comments (Attendees)	
	Specifications will be changing for chemically stabilized roadbeds. New specifications will set a number (plasticity index) for the use of lime and will set another number for the use of cement. Between	

ITEM No.	DISCUSSIONS	PROJECT DATES
	these two numbers, the choice between lime and cement is the prerogative of the contractor. The focus will be the quality of the finished product, rather the ingredients.	
	Most contractor personnel sent to the KYTC QC/QA training are foremen, assistant foremen, or equipment operators moving to one of those positions and most are very competent. All must pass a test at end of training to become certified.	
	Most QORE personnel are college or technical school graduates and are more experienced with the day-to-day testing than KYTC personnel. However, one should remember that KYTC staff perform all types of testing, and therefore, they are more broadly experienced with QA.	
	Quality Control consultants bid on areas for consulting on KYTC project. These regions are divided up into two district segments: D1 & D2, D3 & D4, D5 & D6, D9 & D12, D10 & D11, and D7 & D8. If the consultant wins the bid for that area, they cannot work for any contractor doing work for KYTC in the same region.	
	Action Items	
	Contact in April 2007 for additional information regarding QC/QA specifications, and test data.	

MEETING SUBJECT: Interview 6 Regarding QC/QA: Evaluation of Effectiveness Research Study, Primarily Focusing on Embankment.			
MEETING DATE:	**March 20, 2007**	LOCATION:	**Phone Interview**
PREPARED BY:	**Nicholas Hendrix**	ISSUE DATE:	

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DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Paul Goodrum	University of Kentucky		
Nicholas Hendrix	University of Kentucky		
Kamyar Mahboub	University of Kentucky		
Attendee 1	Kentucky Transportation Dept.		

MEETING PURPOSE

To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	PROJECT DATES
	Introduction	
	Phone conference attendees introduced themselves	N/A
	Background Comments (Attendees)	
1.	Do you have any broad introductory comments regarding QC/QA in Kentucky? Answer: KYTC received federal approval to pursue note 10-V (regarding QC/QA of aggregate) for a limited time as a pilot evaluation. The evaluation was to be completed by January 1, 2007, but due to the lack of data KYTC was unable to meet that deadline. Accordingly, KYTC filed for an extension of the pilot project on February 15.	N/A
2.	What specific projects are we going to discuss today? Answer: N/A	N/A
3.	Which materials (e.g. asphalt, concrete, soil, etc.) on the project are subject to QC/QA specifications? Answer: N/A	N/A
4.	What do you think about the adequacy of QC/QA personnel? Answer: There is adequate staffing for both KYTC and the contractor.	N/A
5.	What do you think about the adequacy of verification? Answer: d. There is actually a third level of scrutiny for verification. For the current note (10-V) the contractor performs Quality Control, KYTC performs Quality Assurance, and KYTC also performs Quality Verification. Quality Verification is a check to assure that the contractor and KYTC Materials have analyzed the same sample population. For verification procedures, he thinks that KYTC is adequately staffed now but probably will not be for long. There seems to be some ambiguity over who is ultimately responsible for Quality Verification. e. Stoppage of a project is not to be taken lightly, but is a tool that can be, and has been, exercised. f. No serious cases with the exception of one project where the	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
	same consultant was responsible for reporting QC/QA/QV.	
	QC/QA Procedures (Attendees)	
6.	Are the testing protocols being followed correctly? <u>Answer:</u> He stated that KYTC has limited experience in aggregate QC/QA. He said that a few pilot projects were started in 2000 and those had mixed results- some favorable and some unfavorable on the correct following of protocols.	N/A
7.	Do you feel the right things are being tested to make sure that a quality finished product is produced? <u>Answer:</u> The testing currently being performed is fine. If, however, all of the QC/QA/QV processes are privatized, the consultants need to perform same tests as KYTC; consultants should basically follow the current note (10-V). Gradations and Densities are the two primary tests.	N/A
8.	Do you feel that the QC/QA practices are applied uniformly across various projects in KY? <u>Answer:</u> We don't really know right now. In years past the central office of KYTC administered the practices to make sure they were performed uniformly across the state. In general, all KYTC district offices do things differently.	N/A
9.	What can be done in order to improve the accuracy of various measurements? <u>Answer:</u> There shouldn't be any testing problems (gradation and density are very elementary). Fraud on behalf of a consultant could be a potential problem. Normally, QA should be done at the district materials lab as a check against the equipment being used by the contractor.	N/A
10.	Do you think testing is done at the right frequency? <u>Answer:</u> Yes. Dudley Brown mandated that one test be performed for every 2000 pounds of base material placed.	N/A
11.	Do you feel current pay adjustments factors are fair? <u>Answer:</u> There are currently no incentives, only disincentives for the contractor. The initial note (10-K) implemented in 1999 had incentives but due to changing administrations, those incentives	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
	aren't in place currently. To settle disputes between the two parties of when sampling should be performed, FHWA has mandated that sampling be done by both KYTC and the contractor at "final point of incorporation". This arrangement is favorable for KYTC but not so much for the contractor.	
	Training (Attendees)	
12.	Are the KYTC staff adequately trained to do their QA job effectively? What types of training would you recommend? Answer: KYTC staff are adequately trained- perhaps "overkill". He wouldn't currently recommend any additional training.	N/A
13.	Are the Contractor staff adequately trained to do their QC job effectively? What types of training would you recommend? Answer: The contractors' staff are adequately trained to do their QC job effectively. The only training that they lack is in Site Manager software. However, if KYTC personnel are doing their jobs correctly, it isn't necessary for the contractor to learn Site Manager.	N/A
14.	Are there enough Quality Managers to oversee projects? Answer: He isn't really sure, but doesn't foresee a lack of Quality Managers in the future due to a growing pool of consultants.	N/A
	QC/QA Subcontracting (Attendees)	
15.	What is the extent of QC/QA subcontracting? Answer: QC/QA subcontracting is growing substantially.	N/A
16.	How are the QC/QA subcontractors performing? Answer: Good in general. There were some initial work or training problems, but those were resolved quickly.	N/A
17.	Are there any possible conflicts of interest? Answer: He isn't aware of any possible conflicts of interest so long as there is a division of work, i.e. the consultant shouldn't work for KYTC and the contractor.	N/A
	Lessons Learned (Attendees)	
18.	Contractor lessons learned through past projects? Answer: N/A	N/A
19.	DOT lessons learned through past projects? Answer:	N/A

ITEM No.	DISCUSSIONS	PROJECT DATES
	There needs to be a clearer explanation of QC/QA. He thinks that the QC/QA process moves the Transportation Cabinet toward Design-Build and consequently "shrinks" state government. We should have an adequate "in-house" KYTC Quality Verification process.	
20.	Were you involved on highway construction projects before KY QC/QA was implemented? If yes, do you think QC/QA is contributing to a better quality finished product? Answer: Yes. It is hard to say. Accompanying QC/QA was a specification for higher gradation, but there is no field test of permeability so an accurate comparison is not possible. It would be hard to determine whether changes in specifications or the implementation of QC/QA contributed to a better quality finished product. Some contractors, monitor their products closely. See Action Items.	N/A
21.	What would you like to see changed in the use of QC/QA on your projects? Answer: There currently are no specifications to change, but it will be important to assure that notes across the state are identical. It will also be important to work on the specifications for sampling frequency. He thinks that KYTC needs to tailor specifications for specific materials. He also points out that note 10-V doesn't address issues of Site Manager software between KYTC Materials and Construction.	N/A
	General Comments (Attendees)	
	April 3rd, 4th, and 5th a Federal QC/QA specialist is coming to Frankfort for a presentation.	
	He made the statement in reference to Question 6, that some of the contractors with unfavorable results in following QC/QA protocols were no longer in the business. His reasoning of why included issues of scheduling, communication with subcontractors, and the fact that consultants didn't raise questions when issues arose with QC/QA.	
	He predicts that a full Design-Build system will be implemented soon at KYTC.	

ITEM No.	DISCUSSIONS	PROJECT DATES
	Action Items	
	Contact Tom Hinkle of Hinkle corporation in regards to the monitoring of products. Timmy Tipton could also serve as a contact.	

MEETING SUBJECT: Interview 7 Regarding QC/QA: Evaluation of Effectiveness Research Study			
		MEETING NO.	
MEETING DATE:	4/20/2007	LOCATION:	**KYTC Division of Materials**
PREPARED BY:		ISSUE DATE:	

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DISTRIBUTION			
ATTENDEES			
Participant	**Company**	**Participant**	**Company**
Attendee 1	Kentucky Transportation Cabinet		
Attendee 2	Kentucky Transportation Cabinet		
Dr. Kamyar Mahboub	University of Kentucky		
Dr. Paul Goodrum	University of Kentucky		
Mr. Jason Enlow	University of Kentucky		
Mr. Nicholas Hendrix	University of Kentucky		

MEETING PURPOSE
To ask questions regarding QC/QA practices in Kentucky.

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ITEM No.	DISCUSSIONS	PROJECT DATES
	Introduction	
	Meeting attendees introduced themselves	N/A
	General Comments from Attendees	
1.	In regards to logging QC/QA data, the attendees indicated some districts are watching over contractor's shoulder while others are simply no logging the data	N/A
2.	In regards to future statistical analysis, they indicated we're headed toward a more statistically based analysis, such as F and T tests comparing the 1 verified sublot to the 3 unverified.	N/A
3.	Kentucky is utilizing QC/QA more than any other state. However, smaller quantity jobs should not use QC/QA.	N/A
4.	Just because we're going to QC/QA doesn't mean there can be a reduction in employees on the DOT side.	N/A
5.	Would like to see an increase in frequency of verification early in the early stages of projects.	N/A
6.	Would like to have all project QC/QA data on one sheet in the data collection program in order to verify the job.	N/A
7.	Would like to see ongoing F and T tests that would calculate along the duration of the job.	N/A
8.	Regarding Kentucky's smoothness incentive, FHWA said it was too much; it is more than other states by comparison.	N/A

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