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QUALIFYING ITEMS OF WORK FOR END-RESULT SPECIFICATIONS: PHASES I AND II

William E. Elmore, Mansour Solaimanian, and T. Kennedy

CENTER FOR TRANSPORTATION RESEARCH
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16. Abstract

The Texas Department of Transportation (TxDOT) is presently using a quality control/quality assurance specification for hot-mix asphalt concrete pavement. There is a strong interest in determining if other construction items can be converted to this type of specification. The purpose of this report is to (1) review the experiences of a large number of key states believed to be using these types of specifications, (2) review the TxDOT standard specifications in order to recommend candidates for development, and (3) develop a recommended QC/QA specification for flexible base. Of the twenty-three states contacted, nineteen cooperated in the survey, the majority of which were willing to provide copies of their specifications. Fifteen specifications have been received. Based on the information obtained from these reviews, nine items have been recommended for consideration by TxDOT.

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by

William E. Elmore, P.E.

Mansour Solaimanian, Ph.D.

Thomas W. Kennedy, P.E., Ph.D.

Project Summary Report 1825-S

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Project title: *Evaluate Items of Work that Could Be Performed Using an End-Result Specification*

Conducted for the

TEXAS DEPARTMENT OF TRANSPORTATION

in cooperation with the

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by the

CENTER FOR TRANSPORTATION RESEARCH
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IMPLEMENTATION STATEMENT

End-result specifications, also identified as performance-based specifications in this report, are presently being used by TxDOT for hot-mix asphalt concrete pavements. Experience with this specification, together with known experiences documented by other state transportation agencies, has resulted in the Department's desire to determine the potential for expanding quality control/quality assurance (QC/QA) type specifications to other construction items. The results of this study indicate that the standard specification items for portland cement concrete for both structures and pavements, base, aggregates, and earthwork are suitable for development and implementation as QC/QA specifications. In addition, a QC/QA specification for flexible base has been developed as part of this study and is recommended for pilot trials.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

PREFACE

This is the combined report originally intended as a two-part report for Project 0-1750, "Evaluate Items of Work that Could Be Performed Using an End-Result Specification." This report contains the updated review of the activities being conducted in several key state transportation agencies, and reviews current TxDOT standard specifications, initially reported in Preliminary Report 1750-1. Response to the recommendations made to the Department in Research Report 1750-1 for those items considered to be candidates for preparation as QC/QA specifications has prompted the Department to develop the QC/QA specification for flexible base.

ACKNOWLEDGMENTS

The success of this project to date was made possible by the helpful input from representatives of the state highway agencies contacted. The support of the project directors, Lauren Guarduno, P.E. (ABL), and Jeff Seiders (MAT), and of the project coordinator, Doug Dillion, P.E., together with the input from the project monitoring committee, has been instrumental in achieving this success.

The authors also gratefully acknowledge the support and assistance provided by the Center for Transportation Research.

There was no invention or discovery conceived or first actually reduced to practice in the course of or under this contract, including any art, method, process, machine, manufacture, design or composition of matter, or any new and useful improvement thereof, or any variety of plant, which is or may be patentable under the patent laws of the United States of America or any foreign country.

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Thomas W. Kennedy, P.E. (Texas No. 29596)
Research Supervisor

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EVALUATE ITEMS OF WORK THAT COULD BE PERFORMED USING AN END-RESULT SPECIFICATION (PHASE I AND PHASE II)

CHAPTER 1. INTRODUCTION

The close interaction and dependency of the information developed in Research Studies 1750 and 1825 have made it desirable to combine the information documented in Report 1750-1 with this report to give a complete history of the data recommendations and specifications presented.

1.1 BACKGROUND AND SIGNIFICANCE OF WORK

As reported in Research Report 1750-1, which represented Phase I of the total project, the terms *end result* and *QC/QA* are frequently used interchangeably by specification-writing agencies. In point of fact, the two are similar in many respects but the adequacy of the final product is measured quite differently and the differences can be very significant. The pure "end result specification" requires that the specifying agency clearly state its desired product, with the agency then leaving it to the contracting party to deliver that product—at which time it is measured for its adequacy. The "QC/QA (quality control/quality assured) specification" is similar in that the specifying agency again states the product it requires and the contracting party proceeds to provide it. In this case, however, there is a continuing measure of the adequacy of the product by means of carefully spelled out measurements that are acceptable to both parties at the beginning of the project. Some state transportation agencies have already, with careful and long-term education and training programs, moved closer from the QC/QA specifications to the end-result type.

It is widely accepted and recognized that the quality of the construction specification is among the most important factors influencing the quality and cost of pavement construction. The move toward QC/QA specifications is motivated by the desire to assure the quality of the finished product at potentially lower costs by placing the responsibility on the contractor for furnishing that product. Quality is judged both by the accuracy and precision in combining the selected properties of the finished product (such as gradation, asphalt content, air voids, etc., for HMAC) and by the manner in which the product is constructed. Accuracy is measured in terms of the proximity of the mean of measured values to target values. Precision is measured in terms of variability of measured values. The primary objective of a QC/QA specification is to communicate to the contractor, in a clear and unambiguous manner, exactly what is required. For this purpose, various statistical measures provide a practical and convenient way to describe the desired end result. The contractor has the principal responsibility for controlling the construction process (quality control), whereas the specifying agency will be primarily responsible for judging the acceptability of the finished product (quality assurance).

A sound QC/QA specification must define and encourage product quality and uniformity by controlling both the mean product levels and the variability of the product in a statistically efficient manner. Uniform quality, consistent within specification limits, is believed to be strongly associated with ultimate performance.

QC/QA specifications use defined target values for job mix formulas, as well as absolute (exact, fixed) or percentile (percent of target value) deviations to control both deviation and variability. Historical data and past experience have been used to identify the important properties to be controlled and to develop the tolerable deviations from target values, including the corresponding pay factors, as provided in the current HMAC QC/QA specifications of the state. In QC/QA specifications the contractor is required to assume risks greater than those required by a recipe approach. Therefore, it is necessary in the development of these types of specifications that the risks are properly balanced between agency and contractor. Logically, if maximum instructions are given to the contractor at every level, a "recipe" specification evolves. In contrast, if minimal instructions are given and performance requirements are maximized, an end-result specification evolves. This shift requires a critical review of all instructions, and the recognition that the requirements imposed on the contractor relate to performance prediction and evaluation.

The Texas Department of Transportation (TxDOT) is actively moving toward the QC/QA specification concept. The Department has progressively developed these types of specifications for hot-mix asphalt cement (HMAC) and is currently exploring the development of a specification for portland cement concrete. In addition, the Department is interested in the development of similar specifications for other construction items and has specifically asked that a QC/QA specification for "flexible base" be developed as a major part of this study. The adoption of these types of specifications implies an agency decision to move toward end-result specifications.

Responses to the survey of states discussed in Chapter 2 indicate that in those states that have moved toward end-result specifications, the contractor has greater responsibility for the quality control and construction methods and techniques. Both the highway agencies and the contractors have for the most part been satisfied with the change.

1.2 HISTORY OF QC/QA SPECIFICATION DEVELOPMENT IN HIGHWAY CONSTRUCTION

The use of quality assurance in specifications for highway construction began in the later 1960s, primarily with input from the Federal Highway Administration (FHWA). Using its own materials and publications, the FHWA, for example, conducted a series of instructional seminars on the basic concepts and proposed benefits of this type of specification approach for the State Highway and Transportation Organizations (1).

These seminars were followed in the 1970s by several national in-depth studies and seminars sponsored and conducted by various organizations, such as The National Cooperative Highway Research Program (NCHRP) (2, 3), the American Society for Testing and Materials (ASTM)(4), the National Asphalt Pavement Association (NAPA) (5, 6), the Federal Highway Administration (7), and the Associated General Contractors of America (AGC) (8). The majority of these reports were a compilation of the experiences and problems encountered in implementing a form of quality control/quality assurance specification (QC/QA) for hot-mixed asphaltic concrete (HMAC). The initial emphasis of the program nationally was in developing QC/QA specifications for HMAC. In 1987 TxDOT initiated a research study with The University of Texas at Austin, Center for Transportation Research, to develop a true end-result specification for HMAC, RS 1168, "Development of End-Result Acceptance Specifications for HMAC." This was modified to a QC/QA-type specification and the results (9) became, in part, the initial basis for the later TxDOT specification Item 3007. The initial concerns about this type of specification were addressed at the workshop "Statistically Based End Result Specifications" (10) in September 1987, conducted by the Texas Hot Mix Asphalt Pavement Association for both TxDOT and contracting personnel.

In the 1987 study for TxDOT, sixteen state transportation departments—Arizona, Arkansas, California, Florida, Illinois, Indiana, Kentucky, Louisiana, Maryland, Minnesota, Montana, Oregon, Pennsylvania, Virginia, Washington, West Virginia—and the Corps of Engineers were contacted and each sent their version of the QC/QA specification for HMAC. A few of these states—Pennsylvania, Virginia, and West Virginia—had been early participants in the process of converting to this type of specification.

1.3 OBJECTIVES OF THE STUDY

The primary objective of this study at this point is to determine which, if any, other construction specifications are legitimate candidates, and, with the approval of the project advisory committee (PAC), develop the draft specifications for the selected items.

The objective is to be accomplished in three primary steps:

1. Survey the present status and experience of many of the original state transportation agencies to determine progress with QC/QA specifications.
2. Review existing TxDOT construction items to determine which might be recommended for modification to QC/QA specifications.
3. Recommend those selections to the TxDOT PAC.
4. Develop a QC/QA specification for flexible base.
5. Develop a generic implementation plan based upon information received from other state highway agencies' experience for continuing TxDOT implementation efforts.

Chapter 2 contains the results of, and summarizes the information received from, the survey of other state agencies. Development of the QC/QA specification for flexible base and recommended procedures for converting additional items to QC/QA specifications are discussed in Chapter 3. Chapter 4 presents the recommendations for future implementation of

QC/QA specifications. Finally, Appendix A documents the responses for the state highway agencies survey and Appendix B presents the recommended QC/QA specification for flexible base.

CHAPTER 2. SURVEY AND ANALYSIS

2.1 SURVEY OF STATE TRANSPORTATION AGENCIES

Twenty-three states were selected to be participants in this survey. We spoke by telephone with personnel in each state transportation agency, asking them a series of questions related to their experiences with QC/QA specifications and their planned future activities in that area. Nineteen were successfully contacted, with fifteen furnishing copies of their specifications. The states selected for contact were:

Alabama	Maryland
Arizona	Michigan
Arkansas	Minnesota
California	Missouri
Colorado	New York
Florida	Oklahoma
Georgia	Oregon
Illinois	Pennsylvania
Indiana	Virginia
Iowa	West Virginia
Louisiana	Wisconsin
Kentucky	

Questions that we asked personnel in each state were the following:

1. What items are being controlled by QC/QA or end-result specifications?
2. What is measured?
3. What measurements are used for pay factors? Are bonuses allowed?
4. Do you require the contractor to submit a quality control plan for approval prior to commencing construction? If so, how is it enforced?
5. Who makes the measurements?
6. Are copies of your specifications available?

2.1.1 Summary of Responses by States Surveyed

Questions 1 and 2: What items are being controlled by QC/QA or end-result specifications? What is measured?

Table 2.1 summarizes the construction items for which each state contacted indicated some level of use. Appendix A documents each state’s response to the questions.

Many of the states contacted have been using performance-based specifications for years, confirming the information reported earlier by the Center for Transportation in a study for TxDOT (reported in 1991). It was also apparent that there is a wide variety in the level of confidence individual states have in the use of these specifications. Some have adopted these specifications for several of their construction items, while other states are, for various reasons, proceeding more slowly.

Question 3: What measurements are used for pay factors? Are bonuses allowed?

There is an equal variation in the specific properties each state considers important for not only quality control but also for pay purposes. Our survey of the states that utilize QC/QA specifications indicated that, for HMAC, most all use asphalt content and in-place density as pay factors. However, with respect to other factors, they differ and use such parameters as gradation for specific sieves, laboratory density, and the voids in the mineral aggregate (VMA, Table 2.3). While the majority utilize the bonus/penalty approach (incentive/ disincentive), a few include only penalties for poor quality work and no bonus for high quality jobs (disincentive, Table 2.2).

Table 2.4 summarizes the measured properties reported for hot-mix asphalt concrete, while Table 2.5 similarly summarizes the measured properties for portland cement concrete. The measured properties for concrete pavement and structures, being almost identical, are combined in this table.

Table 2.1. State items using QC/QA specifications

STATE	**HMAC**	**PCC PVMT**	**PCC STRUT**	**BASE**	**AGG**	**EARTH WORK**	**A/C**
Alabama	x						
Arizona	x	x	x	x		x	
Arkansas	**	**	**	**	**	**	**
California	x						
Colorado	x	x					
Georgia	x						
Illinois	x	x			x		
Iowa	x	*					
Kentucky	x	*			*		
Maryland	x	x	x	x	x		
Michigan	x	x		x	x		
Minnesota	x	x			x		
Missouri	x						
New York	x		***	*			
Oklahoma	x	x	x				
Oregon	x	x	x		x		x
Pennsylvania	x	x					
Virginia	x	x	x				
Wisconsin	x	x	x		x	x	
SUMMARY	19	12	7	4	7	3	2

* Presently working on specification
** Arkansas has 100% QC/QA specifications
*** Abandoned use of QC/QA specification

Table 2.2. Payment type for some of the states

State	Incentive	Disincentive	Payment Based on Tests Conducted by the:
Alabama	Π	Π	Contractor
Colorado	Π	Π	State
Georgia		Π	State
Iowa		Π	Contractor
Kentucky	Π	Π	Contractor
Michigan	Π	Π	Contractor
Minnesota	Π	Π	Contractor
Missouri	Π	Π	State
Pennsylvania	Π	Π	State
Virginia	Π	Π	Contractor
Wisconsin	Π	Π	Contractor

Table 2.3. Parameters used for determination of pay factors in some states

State	AC	Gradation	In-Place Density	Lab-Compacted Density	VMA
Alabama	√		√	√	
Colorado	√	√	√		
Georgia	√	√	√		
Iowa	√	√	√		
Kentucky	√		√	√	√
Michigan	√		√		√
Minnesota	√	√	√	√	
Missouri	√	√	√		√
Pennsylvania	√	√	√		
Virginia	√	√	√		√
Wisconsin	√	√	√	√	√

Table 2.4. Number of states with measured items for HMAC

ITEM	CONTROL	PAY
VMA	11	5
ASPHALT CONTENT	17	14
GRADATION	13	11
DENSITY	14	16
AIR VOIDS	9	5
UNIFORMITY	2	

Table 2.5. Number of states with measured items for portland cement concrete

ITEM	CONTROL	PAY
COMPRESSIVE STRENGTH	7	3
SLUMP	3	
ENTRAINED AIR	4	1
GRADATION	2	1
THICKNESS	3	3
SMOOTHNESS	3	2
STEEL COVERAGE	1	

Questions 4 and 5: Do you require the contractor to submit a quality control plan prior to commencing construction? If so, how is it enforced?

In reviewing the information and specifications furnished by the states we canvassed, it was apparent that references to a "quality control plan" took many forms and, in fact, one state's negative response to this question actually did include specific terms for acceptance testing by the contractor in their specifications. The control plan, in most states, was made a part of the construction and materials item, i.e., "Hot-Mix Asphalt Pavements," "Asphalt Concrete Pavement," etc., while other states have developed separate *quality control* and *quality acceptance items,* which are referred to by like construction items, such as "Selected Material Base Course," "Lime-Treated Base Course," etc. Two states responded by submitting manuals that had been developed for their QC/QA programs. California, for example, has developed a manual specifically for asphalt concrete that includes detailed instructions on all phases of the program, together with pertinent California tests. Oregon's manual on its quality assurance program is much simpler in that it is limited to specifying for each item the requirements for control, verification, and independent assurance, leaving the details to each construction specification.

The following provides examples of the types of wordings used:

West Virginia

401.4.7.1—Quality Control Testing: Quality control of bituminous concrete is the responsibility of the Contractor. The Contractor shall maintain equipment and qualified personnel, including at least one certified Bituminous Concrete Technician, who shall perform all field sampling and testing necessary to determine the magnitude of the various properties governed by the Specification and shall maintain these properties within the limits of the Specification.

Workable Quality Control Plan: The Contractor, or Contractor-Producer, shall design a workable quality control plan, detailing the type and frequency of sampling and testing deemed necessary to measure and control the magnitude of the various properties of *the bituminous concrete governed by these Specifications. This plan, prepared in accordance with MP 401.03.50, shall be submitted to the Engineer prior to production of material under this Specification."*

Oklahoma

Special Provision applying to all types of Asphalt Concrete Pavement. In-Part:

…3. Contractor's Quality Control Plan. Prior to initiation of work the contractor shall prepare a plan to ensure that acceptable quality can and will be obtained. The plan which is to be submitted to the Engineer at the prework conference shall cover all of the items discussed in Sections 411 and 708 of the Standard Specifications. However, the contractor must tailor the plan to meet specific needs of the project. Once accepted by the Engineer the plan becomes a part of the Contract and shall be enforced accordingly. Subsequent changes to the plan may be required by the Engineer in order to adjust to changes in the process or to correct problems in meeting Specification requirements.

2.2 DISCUSSION OF SURVEY RESPONSES

Performance-based specifications for hot-mix asphalt concrete have continued to be used by the majority of the states, even though it is apparent that some have serious reservations concerning the quality of the product being obtained. The reservations expressed are not as much against this type of specification as they are concerns about their success in utilizing them. Pennsylvania, though it has a long history with the QC/QA specification program, has expressed a need to review its complete operation. It is felt that this is needed in order to take advantage of more modern versions that are capable of better and fairer control of the state's products. Maryland expressed a more serious concern: It has specifications for a number of items but personnel there do not believe they are getting a quality product in their use. Michigan has encountered problems with its specifications for concrete and aggregate, while New York abandoned its use of performance-based specifications for portland cement concrete after a few pilot projects. And Virginia is questioning the cost effectiveness of the PCC specifications, while California has hired an outside agency to evaluate that state's use of these specifications (the report is not yet available).

The fact that there are a number of versions and ways to apply performance-based specifications probably explains the apparent wide variation in the application of, and satisfaction with, their use. In discussing this with one of the state material engineers, it was suggested that the terms *QC/QA* and *Performance-Based Specifications* are defined differently by many of the states contacted.

While all of the responses were for QC/QA-type specifications, each was tailored to their state's particular history and needs; the length of the time of experience with these types of specifications also varied.

In general, the specifications we received fell into the following categories:

1. Separate QC/QA specification for each type of material. (base, cement-treated base, lime-treated base, asphalt mixtures, etc.)
2. A general QC/QA specification with individual specifications referring to it by Special Provision
3. Separate QC/QA manual for a specific material plus a specification to apply
4. Quality management program for each type of material placement

There were also two basic methods for determining acceptance and payment:

1. Established upper and lower limits with a schedule for the required “Percent Within Limits” or allowable “Percent Defective”
2. “Absolute Deviation” from specified target values with specified limits for degree of acceptance

For its part, Texas has utilized the form of specification that will stand alone and utilizes “Absolute Deviations.” At present, this is a satisfactory method, but as additional QC/QA specifications are added, it might be advisable to consider developing a general QC/QA specification that will apply to all construction and material items.

A majority of the states interviewed indicated that the adoption and implementation of the Superpave system for HMAC has focused attention on the need for performance-based specifications.

2.3 REVIEW OF TXDOT STANDARD SPECIFICATIONS

The standard TxDOT specifications were reviewed for their potential for modification to the QC/QA-type specification. The cost effectiveness of such changes, based upon input from those states contacted, is almost an indeterminate factor, since the primary reasons for their adoption (in the 1960-70s) have been based upon manpower considerations. There is a definite advantage in allowing the contractor to be more involved in the accomplishment of a successful operation.

CHAPTER 3. DEVELOPMENT OF QC/QA SPECIFICATIONS

3.1 REVIEW OF TXDOT STANDARD SPECIFICATIONS

Following our review of TxDOT's "Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges," we identified the following standard items as logical considerations for conversion to QC/QA type specifications:

Item 132:	Embankment
Item 247:	Flexible Base and other supporting Items
Item 316, 318:	Surface Treatments
Item 330, 332:	Limestone Rock Asphalt Pavement
Item 334:	Hot Mix-Cold Laid Asphaltic Pavement
Item 342:	Plant Mix Seal
Item 345:	Asphalt Stabilized Base (Plant Mix)
Item 360:	Concrete Pavement

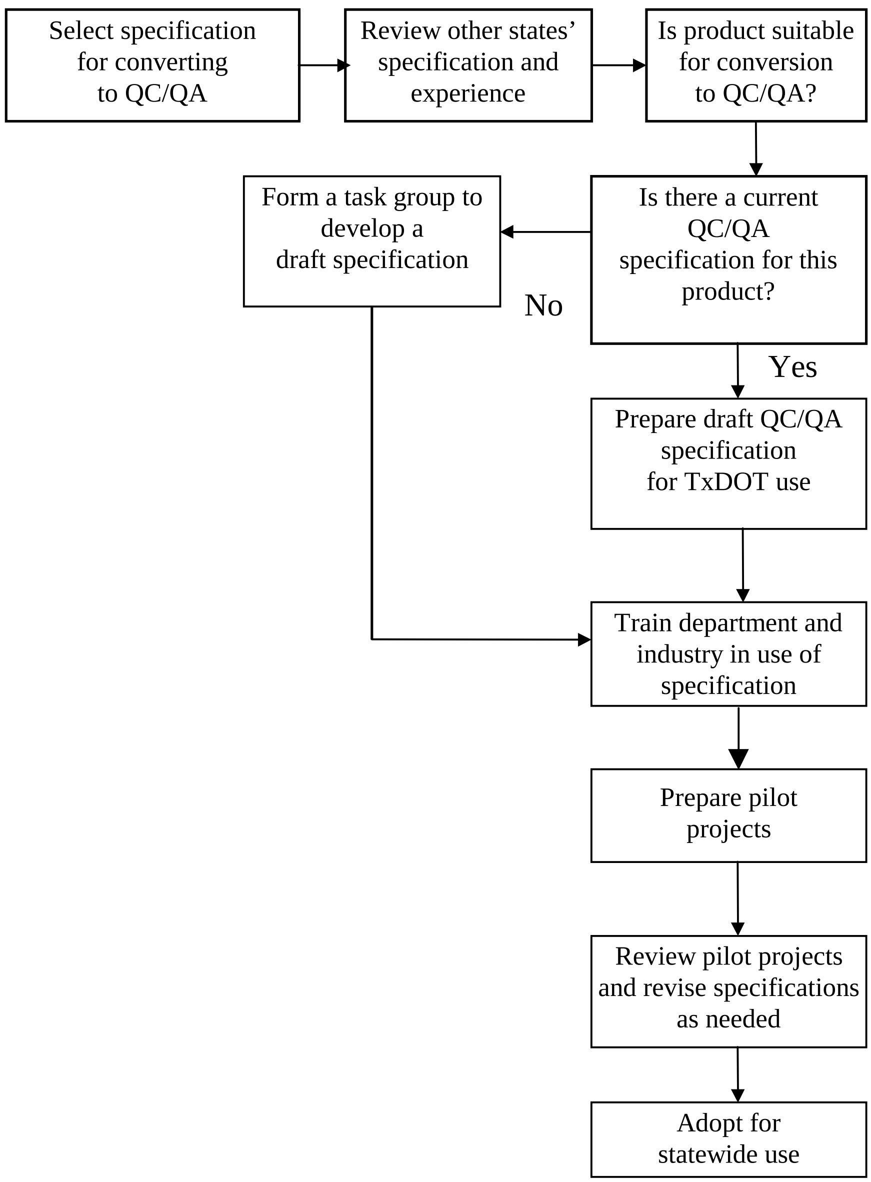
In addition to the above items, it was noted that many items contain common features or materials. A prime example of this is for *aggregates.* All of the items listed above (including items for HMAC and portland cement concrete) have aggregate requirements. Although the individual requirements vary between types of use, they are similar, with most requiring the same test methods for determining and controlling the necessary properties specified in each item. A single specification item for aggregates, which could be used in a manner similar to the way Item 300, "Asphalt, Oils, and Emulsions," (11) is used, could supplement all specification items using asphalt. This could simplify the specifications and provide additional stability to the industry.

3.2 PROCEDURES FOR CONVERTING TO QC/QA SPECIFICATIONS

In any such change it is critical that both industry and department personnel are made a part of the process. Previous regional discussions with department personnel and industry representatives on their experiences with implementing a QC/QA specification for HMAC indicated that greater effort should be made to prepare both parties for the changes in responsibilities (12).

Discussions with other state agencies regarding their experiences made it clear that, even among those agencies having long-term experience QC/QA specifications, there is a continuing evolution or fine tuning of the individual specifications. Most states are still concentrating mainly on one product, namely, HMAC. Efforts to include other products have, in some cases, been aborted or delayed for a variety of reasons. The specification for each product should be carefully reviewed for its suitability for conversion and for the potential benefit to the department.

The following chart is typical of the process used for reviewing and converting existing method specifications to the QC/QA type.



3.3 PREPARATION OF QC/QA SPECIFICATION FOR FLEXIBLE BASE

TxDOT Standard Specification for Item 247, Flexible Base (11), was reviewed and converted to a QC/QA specification following the general steps indicated above in section 3.2. The complete converted specification is presented in Appendix B.

CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Contacts with the other states that are using QC/QA specifications revealed that:

1. There is not a single definition for these specifications presently in use.
2. Each state has adapted the specifications to meet its particular needs.
3. Most of the states contacted used some form of incentive/disincentive pay schedule.
4. Most states are primarily concentrating on QC/QA specifications for HMAC.
5. A slight majority of the states required some form of quality control plan prior to the start of construction.
6. Most of the states were convinced that even with the development problems encountered, converting to QC/QA specifications had yielded satisfactory results. Most of this referred to their HMAC specification experience.

4.2 RECOMMENDATIONS

1. Based on the responses and experiences of the states participating in this review and on the review of the existing TxDOT standards (including the current QC/QA specification for HMAC), we recommend that the following items be considered for conversion to the QC/QA format:

Item 132:	Embankment
Item 316,318:	Surface Treatments
Item 330,332:	Limestone Rock Asphalt Pavement
Item 334:	Hot Mix-Cold Laid Asphaltic Concrete Pavement
Item 342:	Plant Mix Seal
Item 345:	Asphalt Stabilized Base (Plant Mix)
Item 360:	Concrete Pavement

Most of these construction items have other supporting, governing items that will need to be modified.

Input received from the other states, combined with TxDOT's experience with its specification for HMAC, will be important factors in developing these specifications.

2. It is recommended that consideration be given to developing a single aggregate specification for use with base, ACP, portland cement concrete for pavement and structures, and earthwork specifications.
3. Of equal importance in the selection of the items to rewrite is the need to be selective in the type and format of the specifications. These need to be compatible with existing and anticipated policies of TxDOT, in order to allow as smooth a transition as possible.
4. Training seminars should be held for department and industry personnel prior to using the converted specifications.
5. TxDOT shall review and conduct pilot projects with the enclosed specification for flexible base.

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APPENDIX A

DETAIL RESPONSES FROM SURVEYED STATES

SURVEY QUESTIONS:

1. What items are being controlled by QC/QA or End-Result Specifications?
2. What is measured?
3. What measurements are used for pay factors? Are bonuses allowed?
4. Do you require the contractor to submit a quality control plan for approval prior to commencing construction? If so, how is it enforced?
5. Who makes the measurements?
6. Are copies of your specifications available?

Alabama:

1. Use this type of specification on HMAC.
2. Measure asphalt content, voids, laboratory density.
3. Same properties are measured for pay purposes and a bonus is allowed.
4. No response
5. The contractor makes the measurements.

Arizona: Doug Forstie, 602-255-7011

1. They have approximately 10 years' experience using QC specifications with HMAC, PCC pavement and structures, base, and earthwork.
2. With HMAC measurements are made on asphalt content, gradation (4 screens), Marshall voids, and density. For PCC, they are using a new draft that calls for measurements on compressive strengths, thickness, and ride.
3. The same properties are measured for pay factors but only HMAC provides for a bonus.
4. The contractor is not required to submit a QC plan for approval. They originally required one but dropped it, feeling that it was meaningless.
5. Both the contractor and the state make the measurements.

Arkansas: Jim Gee, 501-457-4445

1. They have had 5-6 years' experience with HMAC and, with the publication of their specification book last year, they are now using this type of specification on all items.

California: Bob Doty, 916-654-6228

1. They have been using their present specification for HMAC since 1996, with five projects completed and thirty now active.
2. Asphalt content, gradation, and relative compaction based on job-mix Hveem specimens and nuclear measurements.
3. Same properties are used for pay factors and a 5% bonus is allowed based upon a weighted average.
4. They require a fairly detailed QC plan prior to construction.
5. There is a strong reliance on the contractor's quality control; the state takes its own random samples (there are no split samples).

Colorado: Greg Lowrey, 303-757-9235

1. They have 4 years' experience with HMAC on projects over 5,000 tons. This type of specification has been tried on small portland cement concrete projects.
2. With HMAC they measure asphalt content, aggregate gradation, and in-place density. They are beginning to measure air voids and VMA.
3. For pay factors, only HMAC allows for a bonus at present; asphalt content, gradation, density, and voids are used. A bonus is allowed, with a maximum of 6%.
4. The contractor is required to submit a quality control plan prior to starting operations.
5. The contractor makes the measurements and takes the samples but state results are used for pay purposes.

Georgia: Don Wilson, 404-363-7521

1. They are using this type of specification only for HMAC. They have three Superpave sections in the state so far.
2. Measurements are made on asphalt content, gradation, in-place density, and a range of values for uniformity. On the Superpave sections there have been cases of raising temperatures and adding asphalt and going out of specification. They are using VMA with an effective specific gravity.
3. The same factors are used for pay factors but their state constitution prohibits the payment of a bonus.
4. Presently require a 2-year plant inspection. They are starting to require a quality control plan.
5. The contractor makes the measurements.

Illinois: James Gehler, 217-782-7200

1. They are using this type of specification for HMAC, aggregate gradation, and portland cement concrete (they are investigating its use for base). There is a training program for technicians.
2. The properties that are measured are:
   HMAC: Running average of three for VMA, AC, Dust and Air Voids.
   Portland Cement Concrete: slump, compressive strength, air entrainment.
   Gradation: tight control bands, running average of 5.
3. They do not use pay factors.
4. The contractor is required to submit a quality control plan prior to the start of construction.
5. The contractor makes the measurements and the state runs a duplicate test on 10%.

Iowa: Chan Pak Narotam, 515-239-1101

1. They have been using a form of QC/QA specifications for HMAC since 1992 and have had a favorable experience. Their goal is to have a true QC/QA specification in 2 years. In addition, they currently are developing a specification for portland cement concrete pavement.
2. In HMAC, measurements are made on VMA, voids, AC, and field density (using a quality control index); gradation is sampled at the cold feed. Their goal is to use cores for control measurements with an ignition furnace for the AC in the cores.
3. AC, density, and gradation are used for pay factors. Bonuses are not allowed.
4. The contractor is not required to submit a quality control plan for approval.
5. The contractor takes all the measurements. There are random checks but no plant inspectors.
6. Copies of their specification and Instructional Memoranda are being sent.

Kentucky: James Stone, 502-564-3160

1. They are using QC/QA on all HMAC projects and working on specifications for concrete and aggregates.
2. All projects have lots of 4,000 tons and four cores are taken every sublot of 1,000 tons.
3. Pay factors are based on 25% air voids, 25% VMA, 10% AC, and 40% density.

4. The contractor is required to submit a quality control plan prior to construction, which also includes the aggregate. Compliance is enforced by the state.
5. Presently, KDOT does all job-site testing but plans to switch this to the contractor.
6. Their specifications are still in the development stage and not available.

Maryland: Larry Michael, 410-321-3538

1. They have QC/QA specifications for HMAC, PCC pavement and structures, base, and aggregates.
2. For HMAC, air voids, asphalt content VMA and gradation are measured; for PCC, slump, air content, and strength are measured.
3. Pay factors for HMAC based on gradation and asphalt content. No bonus is allowed so far.
4. A QC plan is required for all items.
5. The contractor makes all QC measurements and the state verifies by nuclear device.

Michigan: Doug Coleman, 517-322-5672

1. They have been using this type of specification for HMAC for 8 years; there have been problems with industry. Similar problems with a concrete specification which they have been trying for 3 years. Now they are starting to develop specifications for aggregate and base in place.
2. HMAC: VMA, gradation, and AC are measured as mix properties at the plant; cores are taken at random. Concrete pavement: Compressive strength, thickness, and smoothness are measured. Aggregate: Density and gradation are measured in place.
3. Pay factors for HMAC are based on the consistency for voids, AC, and the No. 30 and 200 gradation sizes. They are shooting for using VMA. Concrete and aggregate use the same items measured in No. 2. A 10% bonus, a maximum of 6% for in-place density, is allowed. They believe this is probably too broad.
4. The contractor is required to submit a quality control plan prior to construction. The state enforces this with random sampling and testing and tries to maintain inspection forces at the plant.
5. The contractor makes all the measurements.
6. Copies of their specifications will be sent.

Minnesota: Wayne Murphy, 612-779-5590

1. QC/QA specifications have been used for HMAC since 1986 and they now are using them for concrete pavement, redi-mix for concrete pavement, and quality for aggregate. MnDOT has certified plants that are sampled on a random basis.
2. In HMAC, the air voids, VMA, gradation, AC, and in-place density are measured; the contractor does the design. For concrete pavement, the gradation and moist strength are measured and the state does the design.
3. HMAC uses the same properties measured for pay factors for pay factors. Both specifications allow a bonus and in concrete pavement the lower water/cement ratio gets an incentive.
4. Requirement for an approved quality control plan is not enforced although specification appears to require one,
5. Control is by the contractor and assurance is by the state. Sampling and testing is performed at a ratio of 3 to 1.
6. Copies of specifications are to be sent.

Missouri: Gerald Manchester, 573-751-3706

1. They have pilot projects with Superpave and have prepared specifications and training manuals for HMC. The contractors have been trained and testing equipment has been placed in their laboratories.
2. Measurements are made by the state on AC (nuclear), gradation, lab density, cores, and VMA.
3. The same properties are used for pay factors. Bonuses are allowed.
4. Unsure about requiring a quality control plan.
5. Responsibility for making the measurements is not clear.
6. Sending copies of their specifications.

New York: Wayne Bruyle, 518- 457-3240

1. They have used this type for HMAC since 1991 and have also used it for precast concrete drainage units. Previously, they have used it on PCC structures but abandoned this after a few pilot projects; they may look at it again in the future, along with PCC pavements. Some work has been done developing a base specification.
2. For HMAC, air voids, asphalt content, gradation, and VMA are measured. Cores are taken from heavy-duty pavements for density; the nuclear gage is used for regular pavements.
3. For pay factor measurement, core density is used for heavy duty pavement and nuclear gage for regular pavement. All plants are required to be

automated and are depended upon. A bonus is allowed only on the heavy-duty pavements.

4. A QC plan is required for HMAC.
5. The contractor is responsible for QC with a contractor-trained technician at the plant and no resident state inspector at the plant. One-day production equals 1 lot; state takes split sample for test; contractor takes cores and the state tests them.

Oklahoma: Jack Telford, 405-521-2677

1. QC/QA specifications are used on HMAC, PCC pavements, and bridge decks.
2. Measurements are made: HMAC—asphalt content, gradation, laboratory density, road density, and smoothness; PCC pavement—strength, thickness, air content, gradation and smoothness; PCC bridge decks—strength, air content, thickness, smoothness, and depth of cover over steel reinforcement.
3. Same properties are used for pay factors (with a weighted average). A maximum bonus of 5% is allowed.
4. A QC plan is required and acceptance by the engineer is part of the contract.
5. It is allowable to use the contractor's measurements if the state desires but the state is doing most of it now.

Oregon: Ron Noble, 503-986-3050

1. They have had long-term experience with QC/QA specifications for HMAC and PCC for both pavement and structures; also 6-8 years experience with aggregate and liquid asphalt.
2. Standard properties.
3. Same properties and a 5% bonus is allowed with HMAC.
4. No
5. State is presently planning on going to the contractor for QC, with the state to verify.

Pennsylvania: Dean Maurer, 717-787-5229

1. They have used QC/QA specifications for HMAC since the early '80s but believe they may need to re-evaluate these specifications for possible changes. Presently, they have a specification for portland cement concrete and working on one for aggregates.
2. For HMAC, running average measurements are made on AC, aggregate sizes -200 and #8, compacted field density using theoretical Rice's gravity

and sampled behind the paver. For portland cement concrete the slump, air, and strength are measured.

3. Only ACP has pay factors and the AC, -200, and field density measurements are used. The aim is for tight control, though theoretically a bonus of up to 4% is possible.
4. The contractor is required to submit a quality control plan prior to beginning construction.
5. The contractor is directed to take the samples and the state tests them. The inspector does not have to ignore bad areas outside the sampling plan.
6. Copies of their specifications are being sent.

Virginia: Charles Hughes, 804-823-1797

1. QC/QA specifications for ACP and concrete for both structures and pavement. Only a small volume of the pavement concrete so far and they are not sure about the cost effectiveness.
2. Measurements of air voids, VMA, and AC for ACP. The state only takes about 1 out of 3 samples. The quality index for percent within limits as set forth in the AASHTO Guide Specification and QA implementation manual is used.
3. For ACP, the AC is determined by the ignition oven for % within limits, air voids, and VMA for pay factors. For the last 2 years a bonus has been allowed but the Concrete Association wants it deleted.
4. The contractor is required to submit a quality control plan but it is not spelled out clearly. There is a long-term history of using the contractor's test results. The plan is not rigidly enforced.
5. The contractor makes the measurements.
6. Copies of their "within limits" specification will be sent.

Wisconsin: Gary Whited and Curt Johnson, 608-246-5399, 608-266-3751

1. They have quality management for ACP, aggregate for base, sub-base, concrete for pavement and structures, and earthwork. The program has been used for 2 years for concrete structures but the specification for concrete pavement is just starting to be revised.
2. Measurements for ACP are made on % air voids in the compacted mix, gradation, and AC by extraction. Nuclear density is in the new QC/QA specification.
3. No pay factors are presently being used but they are being drafted in the specification for concrete pavement and structures with strength, depth, and ride for pavement, and strength for structures.
4. The contractor is not required to submit a quality control plan but they are looking at one for earthwork.

5. Contractor makes the measurements and there is no planned state involvement.
6. Copies of their specifications are being sent.

APPENDIX B

SPECIAL SPECIFICATION ITEM XXXX
FLEXIBLE BASE

XXXX.1. Description. This Item shall govern for the delivery, stockpiling and/or construction of foundation or base courses as herein specified and in conformity with the typical section and to the lines and grades shown on the plans or established by the Engineer. It shall be constructed on a prepared subbase, subgrade, or other completed base course. It shall be the responsibility of the contractor to provide and place all materials described herein; acceptance by the Engineer will also be as provided herein.

1.1 QUALITY CONTROL: Contractor sampling, testing, and inspection for operational control.

1.2 QUALITY ASSURANCE: Engineer sampling, testing and inspection activities to determine payment and to make acceptance decisions.

1.3 VERIFICATION TESTS: Tests to verify accuracy of quality control, quality assurance, and mixture design testing.

1.4 REFEREE TESTS: Tests used to resolve differences between contractor and engineer test results. The Materials and Tests Division of TxDOT is designated as the referee laboratory.

1.5 INDEPENDENT ASSURANCE PROGRAM: An unbiased and independent evaluation of all the sampling and testing techniques used in the acceptance program. These activities are performed by the engineer. The test results are not used for acceptance.

XXXX.2. Materials. The flexible base material shall be crushed or uncrushed as necessary to meet the requirements herein, and shall consist of durable coarse aggregate particles and binding materials.

(1) General. When off-right-of-way sources are involved, the contractor’s attention is directed to Item 7, “Legal Relations and Responsibilities to the Public.”

(2) Physical Requirements.

(a) General. All types shall meet the physical requirements for the specified grading(s) as set forth in Table 1.

Additives, such as, but not limited to, lime, cement, or fly ash, shall not be used to alter the soil constants or strengths shown in Table 1, unless otherwise shown on the plans.

Unless otherwise shown on the plans, the base material shall have a minimum Bar Linear Shrinkage of 2 percent as determined by Test Method Tex-107-E, Part II.

The flexible base shall be one of the following types:

(b) Type A. Type A material shall be crushed stone produced from oversize quarried aggregate, sized by crushing and produced from a naturally occurring single source. Crushed gravel or uncrushed gravel shall not be acceptable for Type A material. No blending of sources and/or additive materials will be allowed in Type A material.

(c) Type B. Type B material shall be crushed or uncrushed gravel.

(d) Type C. Type C material shall be crushed gravel. Unless otherwise shown on the plans, crushed gravel shall have a minimum of 60 percent of the particles retained on the No. 4 sieve with two (2) or more crushed faces as determined by Test Method Tex-460-A, Part I.

(e) Type D. As shown on the plans.

(3) Pilot Grading. When pilot grading is required on the plans, the flexible base shall not vary more than that specified in the acceptance criteria set forth in the **Subarticle XXXX.4. Quality Control and Acceptance.**

(4) Testing. Testing of flexible materials shall be in accordance with the following Department standard laboratory test procedures:

Moisture Content	Tex-103-E
Liquid Limit	Tex-104-E
Plasticity Index	Tex-106-E
Bar Linear Shrinkage	Tex-107-E, Part II
Sieve Analysis	Tex-110-E
Moisture-Density Determination	Tex-113-E
Roadway Density	Tex-115-E
Wet Ball Mill	Tex-116-E
Triaxial Tests	Tex-117-E
(Part I or II as selected by the engineer)	
Particle Count	Tex-460-A, Part I

TABLE 1. PHYSICAL REQUIREMENTS

GRADE 1	GRADE 2	GRADE 3	GRADE 4	GRADE 5	GRADE 6
Triaxial Class 1: Min. compressive strength, 45 at 0 psi lateral pressure and 175 at 15 psi lateral pressure Master Grading 1-3/4 0 7/8 10-35 3/8 30-50 No. 4 45-65 No. 40 70-85 Max LL 35 Max PI 10 Wet Ball Mill Max 40 Max increase in passing No. 40 20	Triaxial Class 1 to 2.3: Min. compressive strength, psi: 35 at 0 psi lateral pressure and 175 at 15 psi lateral pressure Master Grading 2-1/2 0 1-3/4 0-10 No.4 45-75 No.40 60-85 Max LL 40 Max PI 12 Wet Ball Mill Max 45 Max increase in passing No. 40 20	Triaxial Class - Unspecified Master Grading 2-1/2 0 1-3/4 0-10 No. 4 30-75 No. 40 50-85 Max LL 40 Max PI 12 Wet Ball Mill Max 50 Max increase in passing No. 40 20	Triaxial Class- Unspecified Master Grading 1-3/4 0 No. 4 45-75 No. 40 50-85 Max LL 40 Max PI 12	Triaxial Class- Unspecified Master Grading 1-3/4 0 No. 40 50-85 Max LL 40 Max PI 12	As shown on the Plans

Notes:

1. Gradation requirements are percent retained on square sieves.
2. When a magnesium soundness value is shown on the plans the material will be tested in accordance with Test Method Tex-411-A.
3. When lightweight aggregates are used, the wet ball mill requirements will not apply and the lightweight aggregate shall meet the Los Angeles Abrasion, Pressure Slaking and Freeze-Thaw requirements of Item 303, " Aggregate for Surface Treatment (Lightweight)."

The contractor shall sample and test the base material for triaxial class, soil constants, gradation, and wet ball mill values and furnish these values to the Engineer prior to the compaction operations.

(5) Material Sources. The flexible base material shall be furnished by the Contractor. When a noncommercial source is utilized, it shall be opened in such manner as to immediately expose the vertical faces of all the various strata of acceptable material. Unless otherwise approved by the Engineer, the material shall be secured and processed by successive vertical cuts extending through all of the exposed strata.

Unless otherwise shown on the plans, the flexible material shall be temporarily stockpiled prior to delivery to the roadway. The Contractor shall construct the stockpile in layers approximately two (2) feet in thickness to a height of not less than 10 feet. Prior to delivery to the project site for placement, the Contractor shall provide the Engineer with written documentation that the material meets all applicable tests. In loading from the stockpile for delivery, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

The Contractor may blend materials from more than one (1) source to produce Type B, C, or D flexible base upon furnishing written proof that the combined material meets the specified test requirements.

XXXX.3. Construction Methods. Complete in Place

(1). Preparation of Subgrade or Existing Roadbed. The base course material shall be placed on a completed and approved subgrade or existing base that has been shaped to conform to the typical sections, shown on the plans or established by the Engineer. The work shall be done in accordance with the provisions of applicable bid items.

The subgrade shall be prepared as specified and shall be free from an excess or deficiency of moisture at the time of placing the base course material. Base material will not be placed on a frozen subgrade or subbase.

The Contractor shall correct any soft spots in the existing roadbed or subgrade prior to the placement of base material. The roadbed shall be proof-rolled when shown on the plans.

(2). Placement of Base Material. The base material shall be placed on the prepared subgrade or roadbed and spread uniformly such that when compacted it will conform to the typical section as shown on the plans and the established lines and grades and will have the thickness, width, and cross section shown on the plans.

The material shall be bladed and shaped the same day it is delivered. Spreading shall be performed in such manner that no segregation of coarse and fine particles will exist. All areas of segregated material shall be corrected or removed and replaced as required. Care shall be taken to prevent mixing of subgrade or unspecified material with the base course material during the blading and spreading operation.

Each course shall be thoroughly mixed for the full depth of that course and shall be compacted by any satisfactory method that will produce the required density as shown on the plans. The material shall be maintained substantially at optimum moisture during the mixing, spreading, and compacting operations, water being added or the material aerated as may be necessary. The specified grade and cross section shall be maintained by blading throughout the compaction operation.

The compacted base course shall be tested for depth and any deficiencies corrected by scarifying, placing additional material, mixing, reshaping, and recompacting to the specified density, as directed.

The Contractor shall maintain the base course in a satisfactory condition until accepted.

XXXX.4. Quality Control and Acceptance. To assure that the material meets the requirements of the specifications, certain tests for quality control and acceptance will be performed as specified herein. The properties for which quality control and acceptance testing will be performed are gradation, density, moisture content, plasticity index for the Triaxial Class and Grade, and the thickness and roadway density as shown on the plans. The Contractor shall develop a Quality Control Plan (QCP) and submit this to the Engineer for approval prior to beginning construction. Upon approval by the Engineer, the Plan shall become part of the project specifications and subject to enforcement as such. The QCP may be modified by mutual agreement of the Contractor and the Engineer after the project is underway and after it is apparent such modification will provide improvements in the product.

(1) Quality Control.

a). Control. The Contractor will determine the maximum laboratory density and optimum moisture content together with the additional test results for the stockpiled material proposed for use on the project and submit these results to the Engineer for approval as outlined in **Subarticle XXXX.2.(5).** The roadway density, thickness and grade shall be as shown on the plans and typical sections. The flexible base shall be compacted as necessary to provide not less than 100 percent density, unless otherwise shown on the plans.

The Contractor shall furnish all personnel, equipment, and facilities necessary to perform the required sampling and testing. The Contractor shall provide the Engineer with the opportunity to observe all quality control sampling and testing. All quality control sampling and testing by the Contractor shall be performed by, or under the direct supervision of, a technician prequalified by the Department. Test reports shall be signed and copies made available to the Engineer if requested.

When the material fails to meet the density requirements, or it loses the required stability, density or finish before the next course is placed or the project is completed, it shall be reworked and retested at the expense of the Contractor.

Quality control testing shall be as defined by the QCP, plus added any frequency determined by the Contractor as necessary. However, the Contractor shall be required to perform the acceptance testing as outlined in the following section (b).

b). Acceptance Testing. Acceptance testing for thickness (when specified on the plans), gradation, plasticity index, density, and moisture content by the Contractor will be based on lots. The size of standard lots will be 1,000 tons. Partial lots, of any size may be established by the Engineer at any time. Test methods for acceptance shall be the same as specified for quality control testing. The item of work shall not be considered passing until passing test reports are submitted to and accepted by the Engineer.

The contractor shall take a minimum of one test for all properties in each lot, randomly selected by the Engineer by Test Method Tex-225-F.

If the material being furnished is crushed stone and the results of the first three tests for plasticity index (PI) are acceptable and the results agree with the results of tests made on the stockpiled material specified in subsection **XXXX.2.(5).,** further tests for PI may be waived by the Engineer. If a change in material occurs, either by processing or source, testing for PI will be resumed. If the new material is crushed stone and the results of the first three tests for PI are again acceptable and in agreement with the stockpile tests, the Engineer may waive further PI testing.

In the event visual observation indicates any location appears to be defective, the Engineer may require the Contractor to test that location.

The Contractor’s acceptance sampling and testing results are subject to independent assurance sampling and testing conducted by the Department. Independent assurance and verification sampling and testing will be conducted in accordance with the Department’s Manuals of Procedures. If the Engineer is unable to verify the Contractor’s test results, the Contractor shall be required to make necessary changes in equipment and /or procedures prior to continuing work until agreement is achieved.

(2) Acceptance.

Each lot shall be accepted as described below.

(a). Gradation and Plasticity Index.

(a.1). Stockpiled Sampled Material. Stockpiled material shall be sampled, tested, and accepted before being incorporated into the work. Stockpile material found not in compliance will be rejected and replaced with acceptable material.

(a.2). Roadway Sampled Material. If a lot or a partial lot fails to meet gradation and/or PI requirements, the Contractor , without cost to the Department, shall remove and replace that lot with acceptable material. Tests and acceptance of the replacement material will be the same as required for the original material.

When the material is nonplastic and tests for PI have been waived as specified in subsection **XXXX.4.(b)**,the material will be accepted for PI without additional testing.

(b). Density. When a density requirement is specified, the results of all tests shall be at or above the minimum required density and the moisture content should be at or approximately the optimum. The Engineer may accept the work providing not more than one (1) out of the most five (5) consecutive density tests is below the specified density, and providing that the failing test is no more than three (3.0) pounds per cubic foot below the specified density.

(c). Grade Tolerance. In areas where surfacing is to be placed, any deviation in excess of ¼ inch in cross section or ¼ inch in a length of 16 feet measured longitudinally shall be corrected by loosening, adding, or removing material, and by reshaping and recompacting by sprinkling and rolling.

(d). Thickness Measurement. The material shall be measured for depth by lot or fraction thereof. The measurements will be at location(s) determined by the Engineer and performed in accordance with Test Method Tex-140-E. In any lot where the material is deficient by more than ½ inch in thickness, the deficient area shall be defined and corrected by scarifying, adding material as required, reshaping, recompacting, and refinishing at the Contractor’s expense.

XXXX.5. Measurement and Payment.

(1). Measurement. Measurement will be by the square yard of surface area in the completed and accepted position. The surface area of the base course will be based on the width of flexible base as shown on the plans.

(2). Payment. The work performed and materials furnished in accordance with this Item and measured as specified will be paid for at the unit price bid for “Flexible Base (Complete in Place)” of the type and grade specified. This price shall be full compensation for securing and furnishing all materials, including any royalty and freight involved; for obtaining, preparing, and stockpiling all materials; for all hauling and delivering and for all manipulations; sprinkling for rolling; sprinkling for dust control, for labor, tools including scales if necessary, and incidentals necessary to complete the work. The unit price bid shall be full compensation for shaping and fine grading the roadbed; and for spreading, mixing, blading, compacting, shaping, finishing, and curing the base material.