
Office of the Inspector General

Audit Report

Quality of Construction
Central Artery/Third Harbor Tunnel
Federal Highway Administration
Region 1

Report Number: R2-FH-7-007
Date Issued: December 19, 1996





**U.S. Department of
Transportation**

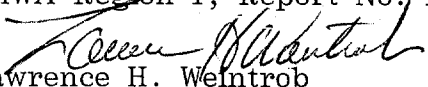
Office of the Secretary
of Transportation

Office of Inspector General

Memorandum

Subject: ACTION: Report on Quality of Construction,
Central Artery/Third Harbor Tunnel,
FHWA Region 1, Report No. R2-FH-7-007

Date: December 19, 1996

From: 
Lawrence H. Weintrob
Assistant Inspector General for Auditing

Reply to
Attn. of: JA-1

To: Federal Highway Administrator

We are providing this report for your information and use. Your October 30, 1996, comments to our July 2, 1996, draft report were considered in preparing this report. A synopsis of the report follows this memorandum.

FHWA agreed with all recommendations, and the actions taken and planned are reasonable. The recommendations are considered resolved, subject to the followup provisions of Department of Transportation Order 8000.1C.

We appreciate the courtesies and assistance extended to our staff during the audit. If you have any questions, or require additional information, please contact me at (202) 366-1992, or Michael E. Goldstein, Regional Manager, Region II, at (212) 264-8701.

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U.S. Department of
Transportation

Office of the Inspector General

***Quality of Construction
Central Artery/Third Harbor Tunnel
Federal Highway Administration
Region 1***

Report No. R2-FH-7-007

December 19, 1996

Objective

The objective of this audit was to evaluate the Federal Highway Administration's (FHWA) oversight of the Central Artery/Third Harbor Tunnel Project's (Project) testing procedures to ensure construction was completed in accordance with applicable specifications.

Conclusion

FHWA provided limited oversight of the Project's testing procedures. Weaknesses were found in the Project's quality of workmanship, disposition of failed materials, implementation of the Massachusetts Highway Department's (State) Materials Manual, and completion of material documents and reports. As a result, the Project incurred \$1,784,000 in additional expenses for repairs and delays due to inferior workmanship, and FHWA did not have reasonable assurance that construction and materials used in the Project were in accordance with applicable specifications.

Monetary Impact

Based on the March 1996 Project Management Monthly Report, only 21 percent of the Project is completed. Construction work has just begun on the Central Artery sections, which will be the most costly and most complicated construction on the Project. Approximately \$5.6 billion of the total \$8 billion required to complete the Project will be spent for construction. Although the monetary effect cited in this report for three contracts is relatively small, the issues raised illustrate weaknesses which have the potential to escalate into larger problems as construction proceeds to completion over the next 8 years.

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U.S. Department of
Transportation

Office of the Inspector General

Recommendations

We recommend the FHWA Administrator instruct the FHWA Massachusetts Division to strengthen oversight of Project testing procedures to ensure construction and materials used in the Project are in accordance with applicable specifications. In addition, FHWA should not participate in Project costs caused by inferior workmanship, and seek reimbursement from the State for any Federal funds already provided for this purpose. We also recommend that FHWA emphasize the need for strict compliance with Project testing procedures and pertinent regulations, including receipt of credits for failed materials, and do not participate in Project costs resulting from overriding contract provisions.

Furthermore, FHWA should require the State to direct Bechtel Civil Inc./Parson, Brinckerhoff, Quade, & Douglas Inc. (Consultant) to provide the Consultant's Technical Services Department the necessary independence and support to perform effective testing of Project construction materials. FHWA should also require the State to ensure that the Consultant responds to Disposition of Materials in a timely and effective manner. Additionally, FHWA should ensure that the Massachusetts Division reviews and formally approves all changes to the Materials Manual prior to implementation. Finally, we recommend FHWA require that, prior to certification, the State assure that material closeout reports include necessary documentation for all materials which have been tested and incorporated into the Project, and review such documentation for compliance with contract specifications.

Management Position

FHWA concurred with the recommendations made in the report, and identified corrective actions to address the weaknesses cited. In addition, FHWA provided general comments regarding quality of construction on the Project.

Office of Inspector General Comments

The actions taken and planned in response to the audit recommendations are reasonable, and the recommendations are considered resolved.

TABLE OF CONTENTS

TRANSMITTAL MEMORANDUM

SYNOPSIS

I. INTRODUCTION

Background.....	1
Objective, Scope, and Methodology.....	2
Management Controls.....	3
Prior Audit Coverage.....	4

II. FINDING AND RECOMMENDATIONS

Finding: Controls Over Testing Procedures.....	5
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III. EXHIBIT

Exhibit: Audit Team Members.....	19
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IV. APPENDIX

Management Response to Draft Report.....	20
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I. INTRODUCTION

Background

Construction on the Central Artery/Third Harbor Tunnel Project (Project) started in May 1991 and will continue until the Project is completed in May 2004. The total unescalated cost for the Project is currently estimated at nearly \$8 billion. The Project is divided into eight sections: Central Area North, Central Area, Central Artery South, South Bay Interchange, Massachusetts Avenue Interchange, South Boston, Third Harbor Tunnel, and East Boston. Federal funding for the Project ranges from 80 to 90 percent and is administered by the Federal Highway Administration (FHWA).

Under its stewardship plan, FHWA is responsible for providing program oversight and accountability for all aspects of the public resources that are allocated to highway planning, design, and construction. In addition, Title 23, Code of Federal Regulations (CFR), Part 637 requires that:

Each State highway agency shall develop a sampling and testing program which will provide assurance that the materials and workmanship incorporated in each Federal-aid highway construction project are in reasonably close conformity with the requirements of the approved plans and specifications, including approved changes. The program must meet the criteria in subsection 637.207, and be approved by the FHWA.

The Management Consultant, Bechtel Civil Inc./Parson, Brinckerhoff, Quade & Douglas Inc. (Consultant), in conjunction with the Massachusetts Highway Department (State) developed a manual for a system to control materials used on the Project. The system is intended to ensure that the materials incorporated into the Project are as specified in the individual construction contract documents.

The Consultant and construction contractors (contractors) control materials on the Project by use of job control procedures. Job control materials are sampled and tested or inspected. Samples are obtained at the job site and either tested or inspected in the field or sent to the Consultant's Technical Services Department (Project Laboratory) for testing.

The Project Laboratory is responsible for determining which method of material control is to be employed for each type of material used on a site, as well as testing the materials. The Project Laboratory issues a Disposition of

Materials (DOM) to the Consultant's resident engineer for materials that are tested but do not meet specifications. Each construction contract has one resident engineer who must review the DOM and decide what action to take regarding the failed material. Based on professional judgment, the resident engineer may reject or accept such material. If the failed material is accepted, the resident engineer can request a credit from the contractor if it is determined prudent.

A contractor's proposal to incorporate failed material must be reviewed and approved by the State's Area Construction Manager. If the proposal is accepted, the manager will sign the DOM, as a one-time acceptance, not a change of specifications for the material for the entire contract. If the manager does not approve the proposal, the resident engineer writes the contractor to remove the unacceptable material.

The results of the material inspection and testing must be documented as evidence that the materials used on the Project met contract requirements, and as support for acceptance of and payment for the materials furnished and work completed. These procedures allow the Consultant to obtain the required Federal and State concurrences at the closeout of the contract. The concurrences provide assurance that materials incorporated into the work comply with contractual requirements, or that use of failed materials has been specifically evaluated, and approved by the State's Area Construction Manager.

Objective, Scope, and Methodology

The objective of this audit was to evaluate the FHWA's oversight of the Project's testing procedures to ensure construction was completed in accordance with applicable specifications.

Audit verification was conducted between December 1995 and March 1996. Based on Federal expenditures, we selected for our sample two large and one medium construction contracts from our universe of 20 construction contracts. The adjusted contract amount totaled \$1.1 billion. The three construction contracts selected totaled more than \$475 million, and included the contracts with the largest and third largest Federal expenditures. The contract with the largest Federal expenditures was also the oldest construction contract of the three reviewed, dating back to 1991. In addition, the contracts represented different types of construction used on the Project such as an underwater tunnel, an underground tunnel, and a haul road. The contracts reviewed included: (1) Interstate 90 (I-90) Immersed Tube Tunnel, contract number

C05A1, \$240,725,228; (2)I-90 Boston Marine Industrial Park Tunnel, contract number C04A2, \$223,509,367; and (3) South Boston Haul Road, contract number C02A1, \$11,010,292.

Our evaluation of test results for concrete construction performed under contract numbers C04A2 and C05A1 concluded the concrete used was basically in compliance with contract specifications. However, we could not observe concrete testing procedures because of the limited amount of concrete construction which took place during audit verification in the winter months.

The audit also included an evaluation of material testing policies and procedures. Federal, State, and Consultant records were reviewed for documentation supporting the testing of materials. In addition, interviews were conducted with Federal, State, and Consultant officials to assess the adequacy of the materials acceptance process and testing results to ensure construction was completed in accordance with applicable specifications.

Our audit was conducted in accordance with Government Auditing Standards prescribed by the Comptroller General of the United States and included such tests of records and other auditing procedures as were considered necessary in the circumstances. Our evaluation of the quality of construction was based on applicable Federal regulations, State laws, and Project procedures. The audit was conducted at the FHWA Massachusetts Division Office (Massachusetts Division) in Cambridge, Massachusetts; State and Project offices; and selected field sites in Boston, Massachusetts.

Management Controls

Our audit included a review of policies, procedures, and practices implemented by FHWA, the State, and Consultant to ensure testing procedures for the Project were adequately controlled. Our review of management controls disclosed significant weaknesses in FHWA's oversight of the State's control of testing procedures used by the Consultant for the Project as discussed in Part II of this report.

Prior Audit Coverage

The Office of Inspector General (OIG) has not performed prior audits of the Quality of Construction on the Project. This audit is one of a series of time-phased audits the OIG has conducted on the Project. Prior audit reports and management advisory memoranda have highlighted examples where the State charged the Federal Government for Project costs which were the result of local political or economic decisions. Examples included acquisition of Project right-of-way, emergency equipment and services, and use of police details. In these cases, the OIG position was that FHWA should not participate in additional Project costs incurred unnecessarily by the State.

II. FINDING AND RECOMMENDATIONS

Finding. Controls Over Testing Procedures

FHWA provided limited oversight of the Project's testing procedures. This condition occurred because FHWA limited its oversight based on its interpretation of Federal regulations which required the State to establish and monitor testing procedures. Weaknesses were found in the Project's quality of workmanship, disposition of failed materials, implementation of the Materials Manual, and completion of material documents and reports. This condition occurred because the State and Consultant did not comply with testing procedures, contractual requirements, and Federal regulations. As a result, the Project incurred \$1,784,000 in additional expenses for repairs and delays due to inferior workmanship, and FHWA did not have reasonable assurance that construction and materials used in the Project were in accordance with applicable specifications.

Discussion

Title 23, CFR, Part 637, Construction Inspection and Approval, prescribes policies, procedures, and guidelines relating to sampling and testing of materials and construction for Federal-aid highway projects. Paragraph 637.205(a) states:

Each State highway agency shall develop a sampling and testing program which will provide assurance that the materials and workmanship incorporated in each Federal-aid highway construction project are in reasonably close conformity with the requirements of the approved plans and specifications, including approved changes. The program must meet the criteria in subsection 637.207, and be approved by the FHWA.

We interviewed the Massachusetts Division Project Manager to determine FHWA's role in providing oversight over testing procedures and the quality of construction on the Project. The Project Manager stated that FHWA had complied with Federal regulations by reviewing and approving the State's Materials Manual, which provides requirements and procedures for materials and workmanship incorporated into the Project. FHWA approved the State's sampling and testing program, as contained in the Materials Manual, on July 22, 1992.

The Division Administrator stated FHWA did not interpret the regulations as requiring indepth monitoring and oversight. Although FHWA conducts monthly inspections which include review of material and testing documentation, FHWA has limited its oversight of testing procedures and relied on the State and Consultant's implementation of the Materials Manual's requirements to ensure construction is completed in accordance with applicable specifications. However, our audit disclosed the State and Consultant did not comply with testing procedures, contractual requirements, and Federal regulations.

In a January 6, 1994, memorandum to the Secretary of Transportation, the FHWA Administrator discussed cost increases on the Project, and stated that, "In view of the major scope of this project, its cost has long been of concern to us." In a statement on March 15, 1994, FHWA agreed to work with the OIG ". . . to protect the investment of Federal funds and ensure completion of the project on time and within budget." Accordingly, it is important that FHWA provide effective oversight of construction activities, which are expected to account for about 70 percent of total Project costs. Our audit disclosed the need for FHWA to strengthen its oversight of testing procedures to ensure the adequacy of construction and materials used on the Project. FHWA and State management controls were not adequate to ensure the quality of construction in the three contracts reviewed and resulted in additional expenses and delays on the Project. Details are provided in the following paragraphs.

Quality of Workmanship

The construction contracts issued by the State for the Project include General Requirements and Covenants of Construction Contracts (General Requirements), which govern the quality of Project materials and workmanship. Section 5.09, Inspection of Work and Administration of Backcharges, establishes criteria for Project construction. The Consultant's resident engineer has the responsibility for ensuring the quality of work performed.

. . . if the Engineer so requests, the Contractor, at any time before Substantial Completion of the Work, shall remove or uncover such portions of the finished work as may be directed. After examination, the Contractor shall restore said portions of the Work to the standard required by the Contract Documents. Should the work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed will be paid for as a

Change Order; but should the work so exposed or examined prove unacceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed, will be at the Contractor's expense. . . .

We determined the Consultant's resident engineer allowed the C04A2 contractor to continue installation of a waterproofing system, despite finding the workmanship inferior. Neither the State nor the Consultant adequately monitored the contractor's installation. The inferior workmanship resulted in ongoing problems with water leaks in the walls and roof of a section of the Boston Marine Industrial Park Tunnel. Furthermore, contrary to State requirements, the Project agreed to share the cost of testing with the contractor, even after the test found the work to be unacceptable. As of February 1996, the problems have resulted in \$1,784,000 of additional Project costs, including \$154,000 for testing, an \$800,000 repair claim, and \$830,000 for follow-on contractor work.

In the hot-applied waterproofing process, a liquid rubberized asphalt membrane is hot-applied to the walls and roof of the tunnel to provide waterproofing, and then covered with backfill materials. The original specification for the waterproofing required an average membrane thickness of 180 mils (1/1000 inch). The contractor began installation in July 1993. On September 1, 1994, a Consultant field architect noted water seeping through the south wall of the "boat section" of the Boston Marine Industrial Park Tunnel. Subsequent measurements, by the Project Laboratory, of the waterproofing thickness at 14 locations on the wall disclosed that 12 locations were less than 125 mils thick and 2 locations were between 125 and 130 mils thick.

Due to concerns raised by the measurements, the Project Laboratory performed an additional six random measurements on the north wall, prior to backfilling, and found the maximum thickness to be only 140 mils. Based on the field architect's observations and the results of the tests, the resident engineer issued Deficiency Report Number 128 to notify the contractor of unacceptable work and deficiencies in the contractor's Quality Control Program. The report recommended the contractor excavate a test pit to check the thickness of hot-applied waterproofing where backfill was placed and provide a repair plan. The contractor was allowed to continue application of the waterproofing, but told to stop backfilling against the structure.

In September 1994, a test pit was excavated, but results proved inconclusive. Because the resident engineer did not specify the depth of the test pit, the

contractor only excavated a shallow pit to approximately mid-depth of the wall. Consequently, the cause of the leaks was not detected and work was allowed to continue.

However, leaks continued in backfilled sections of the tunnel. In December 1994, FHWA representatives observed water filtering into the newly constructed section of the tunnel. FHWA alerted the State that the leaks were unacceptable and requested a formal investigation of the cause of the leaks. FHWA also advised the State to halt additional hot-applied waterproofing until the cause for the failures was identified.

To formally determine the cause, FHWA and the State requested further tests. The contractor was requested to excavate approximately 300 linear feet of the north boat wall having active leakage. This second test pit covered the full depth of the wall and disclosed that much of the wall either had no application of the hot-applied waterproofing material or had significant variations in thickness. A flood test was also conducted at a cost of \$35,000 to determine the performance of the waterproofing system as specified in contract requirements. The system was applied to a portion of the tunnel wall which was then flooded. The test found the system did provide a positive water barrier. The results concluded the materials met the performance specification requirements. Furthermore, the various tests indicated the primary cause of the leaks was due to flaws in the application of the contractor's waterproofing.

The costs of the first and second test pits were approximately \$7,000 and \$112,000, respectively, for a total of \$119,000. In Pending Change Notice (PCN) Authorization Number 122, the State agreed that "If improper application is found to be the problem, the Project will share the cost with . . . (the Contractor) on an equal basis. It is noted that the Department has the right to uncover completed work under Section 5.09 and if fault is found, to have the Contractor pay for the investigation." However, the contractor stated that the water leaks could be repaired from the interior face of the walls (industry practice), without excavation. Subsequently, the Project elected to share costs because it determined that excavation would more quickly identify the root cause of the leaks. Since FHWA participated in half the testing costs, the Federal share was approximately 85 percent of \$59,500 or \$50,575.

In our opinion, the Federal Government should not have participated in the costs of the two test pits. In the first test, given the facts surrounding the leakage problem, the resident engineer should have carefully monitored the contractor's test pit to ensure the excavation was deep enough. The PCN noted that "It is believed that deficiencies would have been found had a deeper

excavation to the invert been made." Since the Project was at fault, it should bear the cost.

In the second test, the Project's determination to share costs equally was a local economic decision which the PCN acknowledged was contrary to contractual requirements. The Project had no valid reason to share the costs of the second test pit since "In this investigation, significant deficiencies were found which were directly attributable to application." If the Project elected to share the cost, the Federal Government should not be expected to participate.

The inferior workmanship also resulted in other Project costs, including a claim and expensive delays and repairs. In its effort to correct the leaks, the contractor expended approximately \$800,000 for repairs, and has filed a claim with the State for reimbursement. FHWA stated that this claim should be resolved by January 1997, when the contract is closed out.

Follow-on contractors installing interior finishes and tunnel systems have been delayed by waiting for completion of leak repairs and extra work to repair water damage. An estimated \$430,000 was needed for I-90 Tunnel Finishes, contract number C05B1, for removal and replacement of water-damaged tiles. About \$400,000 for I-90 Electrical General Contractor, contract number C20A2, was needed to repair damaged cables and conduits. The Project plans to charge the total cost of \$830,000 for follow-on contractor to the C04A2 contractor.

In a February 1996 memorandum to the FHWA Project Manager, the FHWA Area Engineer stated the waterproofing problems arose due to poor workmanship and poor inspection by both the contractor and the consultant. The memorandum further stated that Project field personnel had responsibility for inspection. Under the General Requirements, Section 5.09, the contractor is required to pay for expenses needed to correct unacceptable work. In our opinion, FHWA should not participate in any cost associated with the inferior workmanship, including the original installation, the two test pits, repairs, and follow-on costs resulting from damage or delays due to water leakage. Furthermore, FHWA should seek reimbursement for any funds already provided to the State in connection with the water leakage problem.

Disposition of Failed Materials

The Materials Manual, Revision 1, dated July 25, 1994, Chapter 5, Deviations, requires the Project Laboratory to attach a DOM to the test results for any construction material which falls outside specified limits. The DOM is issued

to the resident engineer, who must resolve the issue, document on the DOM the action taken, and return the DOM to the Project Laboratory for closure. If the contractor requests acceptance of the material as incorporated into the work or provides a remedial proposal, the resident engineer is to forward the request to the State's Area Construction Manager for review and approval. The contractor is to discontinue work in the affected area until the issue is resolved.

Our audit reviewed DOMs issued by the Project Laboratory for materials which failed to meet contract specifications. We found resident engineers disregarded the Project Laboratory's test results and did not follow Materials Manual procedures for processing DOMs for failed tests. The Technical Service Manager advised us that the Project Laboratory was not an enforcement agency and resident engineers were responsible for resolving the issues noted in the DOMs. Furthermore, the Project Laboratory lacked independence and management support to perform its mission. Consequently, the State did not have adequate control over failed materials. Failed materials were incorporated into Project construction, and the Project did not receive appropriate credits for failed materials. Details are provided in the following paragraphs.

State Approval of DOMs - Failed materials were incorporated into the Project without the State's Area Construction Manager's review and approval. For example, contract C04A2 for the waterproofing system on the I-90 mainline east tunnel required application of Swelltite Term Tape. This utility tape provides a protective sealing of the polyethylene sheets and panels which constitute the waterproofing system.

DOMs were issued for six tests which the tape failed to pass. The material in the first two DOMs was not incorporated into the work and therefore did not require State approval. However, the material cited in the next two DOMs was incorporated into the Project without State approval, but were allowed to remain in place because they met reduced specifications provided by the manufacturer. Although the material in the last two DOMs failed to meet even reduced specifications, the material was incorporated into the Project nevertheless. The last two DOMs were issued in September and December 1994, but have not been resolved.

The State's Testing Laboratory Material Coordinator for the Project and the Deputy Project Manager for the Section Design Consultant stated the inferior tape may have caused the leaks in the tunnel floor. The Section Design Consultant insisted the tape was an important part of the waterproofing system, but the manufacturer of the tape denied the tape was

integral to the success of the waterproofing system. Consequently, FHWA and the State requested the Project to retest the inferior tape using test panels in the approved waterproofing system.

In January 1996, the Project Laboratory sent a roll of the inferior tape to an independent laboratory for testing. As of April 1996, the tape had not been tested because of problems with the testing apparatus. The Lead Material Engineer at the Project Laboratory informed us that the Project Laboratory had been relieved of responsibility over the term tape. He stated he had been told that the resident engineer was in charge of the contract and was responsible for resolving the issue of Swelltite Term Tape.

This incident illustrated the Project Laboratory's lack of independence and support from management. Both the Project Laboratory and the resident engineers report to the Consultant's Deputy Project Manager for Construction. The Project Laboratory's role in testing Project construction material has been diminished by the Consultant's decision to increase the responsibility of resident engineers for failed material.

Although the cost of Swelltite Term Tape used in the Project is only \$6,300, cost is not the issue. Since DOM procedures were not followed, the Project needs to determine whether inferior tape caused leaks in the waterproofing system and if failed material incorporated into the work will degrade the quality of construction.

Credits For Failed Materials - The Project did not receive appropriate credits for failed materials because resident engineers did not follow the procedures under the construction contracts' General Requirements. Section 5.03, Conformity with Plans and

Specifications, states:

All Work performed and all materials furnished shall be in accordance with the Contract Documents.

Where definite tolerances are specified in the Contract Documents, such tolerances shall fix the limits of reasonably close conformity. Where tolerances are not specified in the Contract Documents, the Engineer will determine the limits of reasonably close conformity in each individual case and the Engineer's decision shall be final and conclusive.

In the event the Engineer finds the materials or the finished product in which the materials are used not within reasonably close conformity with the plans and specifications but that reasonably acceptable work has been produced, he shall then make a determination if the work shall be accepted and remain in place. In this event, the Engineer will document the basis of acceptance by Change Order which will provide for an appropriate adjustment in the Contract Price as Engineer deems necessary to conform to Engineer's determination based on Engineer's judgment, and in accordance with current construction practices.

Our audit disclosed two instances where the Project did not obtain appropriate credits for failed materials. Contract number C02A1 required application of shotcrete, which is concrete pneumatically projected at high velocity onto a construction surface. The contract requires the average compressive strength of three cores from a test panel to equal or exceed 5,000 pounds per square inch (PSI), with no individual core less than 88 percent of the 5,000 PSI or 4,400 PSI.

We found the shotcrete did not meet contract specifications in 7 of the 53 test panels. Since the seven panels were not within reasonably close conformity, we questioned why the Project did not obtain a credit for the inferior material used on the contract. The resident engineer stated shotcrete was applied for cosmetic purposes, not structural reasons, and therefore a credit was not necessary. In our opinion, the resident engineer should have required a credit, since the Project paid the full amount for the work and was entitled to a product in full conformance with contract specifications.

In another example, the Project obtained an inappropriate form of credit for failed material. The contractor on contract number C05A1 provided crushed stone which was 1 percent below the specified range. On November 19, 1993, the Project Laboratory prepared a DOM, but commented that the material should be considered satisfactory because the deviation was slight and should not effect the intended use. Based on the Project Laboratory's comments, the resident engineer incorporated the material into the work.

On November 29, 1993, the DOM was closed, with no mention of a credit. However, in February 1995, the resident engineer issued a Deficiency Report and a letter to the contractor for the failed crushed stone. The documents stated that the material has served its intended purpose and the State had agreed to accept a field shack from the contractor in lieu of a credit for the failed material. We determined the Project had not attributed a dollar value to the failed material, the field shack's approximate value was \$1,500 to \$2,000. When we discussed this exchange with FHWA, we learned FHWA was not aware of the transaction. Furthermore, the FHWA Project Manager explained that although the Project was not required to obtain a credit for each failed material, receiving a field shack instead of a contract credit was not appropriate under any circumstances.

DOM Resolution Time - The Project Laboratory did not ensure failed materials were resolved timely. In November 1993, the Consultant's Deputy Project Manager of Construction issued a memorandum requiring the Project Laboratory to track unsatisfactory test results and generate a report identifying all unresolved DOMs for each contract. In addition, the memorandum required DOMs to be resolved and closed within 30 days.

In June 1994, the Consultant's Quality Assurance audit concluded that DOMs and failed tests needed to be tracked and monthly reports issued. Our audit noted continuing problems with resolution of DOMs. The time to resolve the DOMs in our audit sample ranged from 0 days up to 29 months. Two of the contracts reviewed, contract numbers C04A2 and C05A1, had a total of 191 DOMs, of which 126 required 1 or more months to resolve. When we questioned the time frames for resolution of DOMs, the Technical Service Manager explained that the Project Laboratory was not an enforcement agency, and resident engineers were responsible for resolving issues noted in the DOMs.

Approval of Materials Manual

The Project implemented changes to the Materials Manual prior to formal FHWA approval. The CFR requires each State highway agency to develop a sampling and testing program. The sampling and testing program must be approved by FHWA and provide assurance the materials and workmanship incorporated in each Federal-aid highway construction project are in reasonably close conformity with the requirements of the approved plans and specifications.

The Materials Manual establishes a system for the control of materials used on the Project and also provides the sampling and testing program for the Project. The manual includes the Guide Schedule for Sampling and Testing Materials that indicates the required tests, the minimum frequency for sampling and testing, and the required sample size.

In September 1993, FHWA conducted a Process Review of Materials Control for the Project. FHWA noted the Consultant had made changes to the Guide Schedule without obtaining FHWA formal approval. The State responded in January 1994, stating revisions to the last approved Guide Schedule, Revision 0, were primarily changes in test quantities and the basis of acceptance of materials.

Although FHWA informed the State that all future revisions to the Materials Manual must be approved by FHWA prior to implementation, the Consultant made subsequent changes prior to obtaining FHWA formal approval. During our audit, we found that in January and March 1995, the Consultant had implemented several changes to Revision 1 of the Materials Manual, dated July 1994, without obtaining FHWA formal approval. For example, on contract C04A2, the certificate requirement for 301 materials had been eliminated. After we notified FHWA, FHWA reviewed the changes and gave formal approval to Revision 2 of the Materials Manual in September 1995.

Material Closeout Reports

Material closeout reports did not include all materials which have been tested and incorporated into the Project. This occurred because the Consultant did not follow the Materials Manual, Chapter 6, Materials Closeout. As a result, FHWA and the State did not have assurance that the materials used in the Project complied with contract specifications as required for acceptance by the Federal Government for reimbursement to the State.

Title 23, CFR, Part 637, requires the State to prepare and submit to FHWA a material certification at completion of the construction contract. The certification is to attest that:

The results of the tests on acceptance samples indicate that the materials incorporated in the construction work, and the construction operations controlled by sampling and testing, were in conformity with the approved plans and specifications. .

..

According to the Materials Manual, the closeout process reviews materials which have been incorporated into the work to assure that materials used were in compliance with contract specifications and that the proper controls have been met.

The materials closeout report provides the documentation to support the State's certification of the materials used in the work. The resident engineer prepares the final report and submits it to the Project Laboratory for concurrence. The Project Laboratory forwards the report to the State for final review and approval. The State's Chief Materials Engineer documents the State's approval by signing the Material Testing Certification form.

We reviewed material closeout reports for construction contracts C05A1 and C02A1 and found these reports did not contain all the necessary documentation. For example, the materials closeout report for contract number C05A1 did not include 488 concrete test reports. Similarly, the materials closeout report for contract number C02A1 did not include 53 test reports representing 272 cubic yards of shotcrete. As discussed previously in this report, the shotcrete used in this contract failed in 7 of the 53 test panels.

According to the Project Laboratory's Lead Materials Engineer, all test results should be included in the material closeout report, especially tests that fail. He stated that not including the test results in the material closeout reports was an oversight. The State Laboratory's Testing Material Coordinator was very concerned about the missing test results because the State relies on the reports to certify the materials used were in compliance with contract specifications. In our opinion, the material closeout process represents the last opportunity for the State to ensure construction on the Project was completed in accordance with applicable specifications. For this process to be an effective internal control, the closeout reports must be complete and accurate.

Conclusion

Based on the March 1996 Project Management Monthly Report, only 21 percent of the Project is completed. Construction work has just begun on the Central Artery sections, which will be the most costly and most complicated construction on the Project. Approximately \$5.6 billion of the total unescalated \$8 billion required to complete the Project will be spent for construction.

Although the monetary effect cited in this report for three contracts is relatively small, the issues raised illustrate weaknesses which have the potential to escalate into larger problems as construction proceeds to completion over the next 8 years. Accordingly, the weaknesses should be addressed now while construction is still in an early stage. FHWA, the State, and the Consultant must work together closely to ensure construction and materials used in the Project are in accordance with applicable specifications.

When the Project awards construction contracts, it pays for work to be in full conformance with applicable specifications. If the work performed or the material used do not meet these specifications, the Project is entitled to and should seek a credit, even if the subspecification work or material is accepted. FHWA needs to ensure that Project management and resident engineers understand the need for strict compliance with Project testing procedures and pertinent regulations. In addition, the Project Laboratory should have the independence and support to effectively perform its testing mission. Furthermore, FHWA should emphasize that the Federal Government will not participate in Project costs resulting from overriding contract provisions.

Recommendations

We recommend the FHWA Administrator:

1. Instruct the Massachusetts Division to strengthen oversight of Project testing procedures to ensure construction and materials used in the Project are in accordance with applicable specifications.
2. Not participate in Project costs associated with inferior workmanship, and seek reimbursement from the State for any Federal funds already provided for this purpose.
3. Emphasize the need for strict compliance with Project testing procedures and pertinent regulations, including receipt of credits for failed materials,

and do not participate in Project costs resulting from overriding contract provisions.

4. Require the State to direct the Consultant to provide the Project Laboratory the necessary independence and support to perform effective testing of Project construction materials.
5. Require the State to ensure that the Consultant responds to DOMs in a timely and effective manner.
6. Ensure that the Massachusetts Division reviews and formally approves all changes to the Materials Manual prior to implementation.
7. Require that, prior to certification, the State assure that material closeout reports include necessary documentation for all materials which have been tested and incorporated into the Project, and review such documentation for compliance with contract specifications.

Management Response

FHWA concurred with all recommendations. FHWA agreed to identify appropriate follow-on review activities as part of the Massachusetts Division's Fiscal Year 1997 work plan, hold periodic materials monitoring coordination meetings with the State and Consultant, and not participate in costs associated with inferior or substandard quality of workmanship. In addition, the State recently rewrote a portion of the Project Material Manual and Resident Engineers' Manual strengthening the language relevant to Project testing procedures and regulations. The State will also rewrite the manual to require more timely resolution of DOMs.

The State assigned an engineer within the Construction Directorate to provide support to the Project Laboratory, serve as a liaison between the two organizations, and followup on material quality issues. Furthermore, FHWA will coordinate proposed changes to the Materials Manual with the State and encourage the State to formalize revisions in a more timely manner.

The State also incorporated into its Materials Manual, the requirement for an interim materials closeout report at the 75 percent physical construction completion stage. The State is to review the interim report and comments are to be resolved by the resident engineer. Upon completion of construction (100 percent), all supporting compliance documentation will be incorporated into the final materials closeout report.

FHWA's entire response, which addressed the audit recommendations and provided additional general comments, is included as an appendix to this report.

Audit Comments

The actions taken and planned in response to the audit recommendations are reasonable, and the recommendations are considered resolved.

AUDIT TEAM MEMBERS

The following is a listing of the audit team members who participated in the audit of Quality of Construction, Central Artery/Third Harbor Tunnel.

Michael E. Goldstein	Regional Manager
Jeffrey Ong	Project Manager
Rodolfo E. Perez	Engineer Advisor
Edward Angeli Jr.	Auditor-in-Charge
Kathleen Peer	Auditor
Karen Lowe	Auditor
Catherine Holmes	Auditor
Virginia Price	Administrative Support



U.S. Department
of Transportation
**Federal Highway
Administration**

Memorandum

Subject: **INFORMATION:** Office of Inspector General
(OIG) Draft Report on Quality of Construction,
Central Artery/Third Harbor Tunnel (CA/T)

Date: October 30, 1996

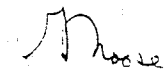
From: Associate Administrator for Administration

Reply to
Attn of: HMS-11

To: Mr. Raymond J. DeCarli
Assistant Inspector General for Auditing (JA-1)

Attached are Federal Highway Administration (FHWA) comments on the OIG's draft report on Quality of Construction on the CA/T. The attached response first addresses the OIG's specific recommendations, then provides additional information under the heading of "general comments" which we would like the OIG to incorporate into the final report.

We appreciate the opportunity to comment on the draft report and apologize for our delayed response.


George S. Moore, Jr.

Attachment

RESPONSE TO SPECIFIC OIG RECOMMENDATIONS

Recommendation 1: Instruct the Massachusetts Division to strengthen oversight of Project testing procedures to ensure construction and materials used in the project are in accordance with applicable specifications.

FHWA Response: Concur. FHWA will strengthen the oversight of Project testing procedures by identifying appropriate follow-on review activities and strategies as part of the Massachusetts Division's FY 1997 Work Plan. In addition, FHWA will set up periodic materials monitoring coordination meetings with MHD and the Consultant. The intent of the meetings would be to provide a forum between the organizations and the units within the organizations on Materials Control issues. The MHD and the Consultant have already agreed to initiate the latter concept as a mechanism to improve overall materials management. The first meeting was held in July and the meetings have continued since then on a monthly basis.

Recommendation 2: Not participate in project costs associated with inferior workmanship, and seek reimbursement from the State for any Federal funds already provided for this purpose.

FHWA Response: Concur. The FHWA has not and will not participate in costs associated with inferior or substandard quality of workmanship. Moreover, the FHWA continues to increase its vigilance and oversight in monitoring the quality of construction materials on CA/T contracts for Federal-aid participation. In the event that reimbursement is appropriate, FHWA will not hesitate to request such a reimbursement.

Recommendation 3: Emphasize the need for strict compliance with Project testing procedures and pertinent regulations, including receipt of credits for failed materials, and do not participate in project costs resulting from overriding contract provisions.

FHWA Response: Concur. The MHD has recently rewritten a portion of the CA/T Materials Manual (Revision 2) and Resident Engineers' manual strengthening the language relevant to Project testing procedures and regulations. The FHWA continues to expect credits where appropriate for failed materials. FHWA will emphasize the subject point in future correspondence to MHD and in our follow-up review activities.

Recommendation 4: Require the State to direct the Consultant to provide the Project Laboratory the necessary independence and support to perform effective testing of project testing materials.

FHWA Response: Concur. The MHD has recently assigned an engineer within their construction Directorate to be responsible for Materials. The primary focus of this engineer's duties will be to provide support to the Project Laboratory and enhance the liaison between the two organizational units. This individual will be responsible for the coordination of the two units with respect to materials control and follow-up on material quality issues.

Recommendation 5: Require the State to respond to DOMs in a timely and efficient manner.

FHWA Response: Concur. We agree that this should be addressed through the rewrite of the Materials Manual. Language will be included to address the issue of more timely resolutions of DOMs. With the new Materials Coordinator in the Construction Division, the number of unresolved DOMs has been substantially reduced.

Recommendation 6: Ensure that the Massachusetts Division reviews and formally approves all changes to the Materials Manual prior to implementation.

FHWA Response: Concur. The Division has always been involved in a proactive approach towards effecting changes to the Materials Manual. As in the past, proposed changes will be coordinated with the Massachusetts Division. We will, however, encourage the MHD to formalize the Revisions in a more timely manner.

Recommendation 7: Require that prior to certification, the State assure that material close out reports include the necessary documentation for all materials which have been tested and incorporated into the Project, and review such documentation for compliance with contract specifications.

FHWA Response: Concur. The MHD has already incorporated into Revision 2 of the CA/T Materials Manual, (6.1), an interim materials close out report at the 75 percent physical construction completion stage. This report is forwarded to the MHD Research Materials Section (RMS) for review. The RMS comments, if any, are resolved by the RE and, upon completion of construction (100 percent), all supporting compliance documentation is incorporated into the final materials close out report. The "Materials Certification" is based on this coordination so as to improve complete supporting documentation.

GENERAL COMMENTS

While concurring with all of the OIG's specific recommendations, the FHWA would like to share some observations which clarify and/or correct statements included in the draft report, which we would like to have included in the final report. These are summarized below:

□ *Overall Assessment of Quality*

FHWA disagrees with the OIG's contention that the quality of the workmanship on the CA/T Project is inferior and has escalated Project costs. FHWA believes that these are broad generalizations and maintains that the referenced isolated incidences are not representative of the overall quality of work on the Project.

□ *Recovery of Inappropriate Charges*

Although apparently not obvious from the specific documents that the OIG reviewed, FHWA and MHD recovered costs for repair of the water leaks by back charging the responsible contractor. FHWA did not participate in the \$1.784 million identified by OIG for follow-on contract work to

correct damage caused by these water leaks. Specifically, FHWA does not participate where materials do not comply with contract specifications.

□ *Ability to Make Appropriate Pay Adjustments*

In the case of materials not conforming to the contract requirements or specifications, FHWA works with the specifying agency (MHD and the Management Consultant) on a case by case basis to reach the most reasonable engineering decision that is in the public interest. While this often means the rejection of material, it may also mean that the material is accepted with appropriate reduction in pay.

□ *FHWA Approvals of Materials Manual Revisions*

The MHD formally submits provisional revisions to the Materials Manual to FHWA for approval. Accordingly, the Division and Regional Offices review each aspect of the changes incorporated in the Materials Manual to assure compliance with applicable standards set forth under the American Society for Testing and Materials (ASTM) and to assure quality assessment of CA/T Project construction materials. The development of Revision 2 of the CA/T Materials Manual occurred with one year of detailed involvement by the FHWA's Regional and Division offices before it was officially approved on September 12, 1995. Contrary to the OIG's finding, this Revision (2), submitted on August 11, 1995, updated the CA/T internal materials control system and was approved by FHWA before incorporation on all CA/T contracts.

□ *Independence of Laboratory*

While the OIG report focused solely on the Technical Services Department (TSD) Lab for Project testing, sampling, and acceptance of construction materials, FHWA believes that the OIG examination should have included the roles of other technical professionals whose responsibilities collectively, along with the TSD, ensure contract specification requirements are met or that issues are appropriately addressed on the CA/T Project. When viewed in total, FHWA believes that the respective roles and responsibilities assigned to each of these parts of the team comprise a system that provides appropriate oversight.

Contrary to the OIG's contention . . . "that the Project Laboratory lacks independence and support from management," FHWA believes the Laboratory receives appropriate management support as one part of the overall materials control system.