Highway Bridge Inspection: State-of-the-Practice Survey

FHWA-RD-01-033

APRIL 2001

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Visit TFHRC's NDEVC website at www.tfhrc.gov/hnr20/nde/home.thm

Highway Bridge Inspection: State-of-the-Practice Study

FHWA-RD-01-033

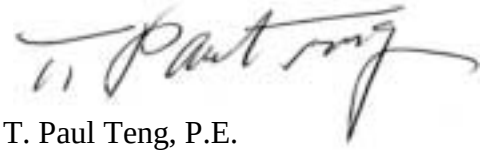
APRIL 2001

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

FOREWORD

This report documents the findings of a State-of-the-Practice Survey for the inspection of highway bridges. State Departments of Transportation (DOTs) were the primary agencies surveyed, however, local DOTs and contractors were also surveyed. Information sought included data regarding the typical compositions of bridge inspection teams, administrative requirements placed upon bridge inspections, and use of nondestructive evaluation during bridge inspections. This report will be of interest to bridge engineers, designers, and inspectors who are involved with the inspection of our Nation's highway bridges.



T. Paul Teng, P.E.
Director, Office of Infrastructure
Research and Development

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-RD-01-033		

4. Title and Subtitle	5. Report Date
HIGHWAY BRIDGE INSPECTION: STATE-OF-THE-PRACTICE SURVEY	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Moore, Mark, PE; Dennis Rolander; Benjamin Graybeal; Brent Phares, Ph.D.; Glenn Washer, PE	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Wiss, Janney, Elstner Associates, Inc. 225 Peachtree St. N.E., Suite 1600 Atlanta, GA 30303	11. Contract or Grant No. DTFH61-96-C-00054
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address NDE Validation Center Office of Infrastructure Research and Development Federal Highway Administration 6300 Georgetown Pike McLean, Virginia 22101-2296	Final Report November 1998 – February 2000
	14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Contracting Officer's Technical Representative (COTR): Glenn Washer, PE, Program Manager, NDE Validation Center

The authors wish to recognize the State Departments of Transportation, the FHWA Division Bridge Engineers, Iowa county Bridge Engineers, and the contractor respondents for taking the time to complete this survey.

16. Abstract

The congressionally mandated National Bridge Inspection program requires States to periodically inventory, inspect, and rate all highway bridges on public roads. The National Bridge Inspection Standards, implemented in 1971, prescribe minimum requirements for the inspection of highway bridges in the United States. Visual Inspection is the primary tool used to perform these inspections.

A survey was conducted to help determine current policies and practices that may affect the accuracy and reliability of Visual Inspection. The survey had three main objectives. The first objective was to compile a state-of-the-practice report for bridge inspection, particularly as it pertains to Visual Inspection. The second objective was to gather information on bridge inspection management to study how inspection management may influence the reliability of inspections. The final objective was to gather data about the current use of nondestructive evaluation technologies and to identify current and future research needs.

Participants included State departments of transportation, as well as some local-level departments of transportation (the 99 Iowa counties) and select bridge inspection contractors. Responses were received from 42 State departments of transportation, 72 Iowa county departments of transportation, and 6 inspection contractors. The combined response rate for the three target groups was 72 percent.

Results from the questionnaires are presented in a question-by-question format. The motivation behind each question and the response percentages for each question start the discussion, followed by the results obtained. Included within each question are comments that will highlight the results.

17. Key Words	18. Distribution Statement
Bridges, Inspection, State-of-the-Practice, Routine Inspection, Visual Inspection, Nondestructive Evaluation (NDE), National Bridge Inspection Standards (NBIS).	No restrictions. This document is available to the public through the National Technical Information Service, Springfield Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	81	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The congressionally mandated National Bridge Inspection program requires States to periodically inventory, inspect, and rate all highway bridges on public roads. The National Bridge Inspection Standards (NBIS), implemented in 1971, prescribe minimum requirements for the inspection of highway bridges in the United States.[1] Visual Inspection is the primary tool used to perform these inspections. No comprehensive research has been performed; however, with regard to the reliability of Visual Inspection of highway bridges. This research study, performed by the Federal Highway Administration's (FHWA) Nondestructive Evaluation Validation Center (NDEVC), focused on evaluating current policies and practices that may affect the reliability of Visual Inspection.

The survey of current policies and practices of Visual Inspection had three main objectives. The first objective was to compile a state-of-the-practice report for bridge inspection, particularly as it pertains to Visual Inspection. The second objective was to gather information on bridge inspection management and assess how inspection management may influence the reliability of inspections. The final objective was to gather data about the current use of nondestructive evaluation (NDE) technologies and to attempt to identify current and future research needs. The target participants for this survey included State departments of transportation (DOTs), county DOTs from Iowa, and select bridge inspection contractors. In general, the same questionnaire was used for each of the three participant groups. Where slight modifications to the questions were required, these are discussed in the Survey Results section of this report.

Information learned from previous studies of NDE use for highway bridges is presented first. The survey conducted by the NDEVC is then described, which includes a brief description of the questionnaires, target groups, and participation. Survey results are then presented in a question-by-question format, with a short discussion of the results. Finally, a summation is presented that highlights significant findings.

PREVIOUS SURVEYS

Three previous surveys on the application of NDE to highway structures were identified during a literature search. Relevant findings from these studies are summarized in this section. The previous surveys included a 1994 study by the California Department of Transportation (Caltrans), a study by Rens, et al. for the American Association of Railroads, and a follow-up study by Rens and Transue. These surveys had broad scopes and provided only limited information related to Visual Inspection.

CALTRANS, 1994 (Unpublished Data)[2]

In 1994, Caltrans conducted a survey targeted at State DOTs. Thirty-seven States responded to this questionnaire. The survey asked nine questions about nondestructive testing (NDT), focusing on what types of tests are used, what corresponding procedures are used, and who performs the tests.[2]

Question 1 asked whether NDT methods were currently used in State DOT bridge inspection programs. If only Visual Inspection was used, a note to that effect was requested. Responses are summarized in table 1 by the technique cited. The Caltrans summary indicated that 19 of the DOTs responded affirmatively regarding Visual Testing. The remaining 18 responses either were non-specific about which type of NDE was used or indicated specific NDT techniques other than Visual Testing. These 18 responses were equally divided between these 2 categories. It should be emphasized that while this question asked about NDT use in general, it was assumed that study participants all used Visual Inspection. However, responses are compiled in terms of Visual Testing, which is a slightly different concept. The American Society for Nondestructive Testing (ASNT) reference ASNT-TC-1A defines Visual Testing as the use of boroscopes, microscopes, and other optical devices to aid Visual Inspection.[3] The more common definition of Visual Inspection includes all unaided inspection/evaluation techniques that use the five senses with only very basic tools (for example, flashlights, sounding hammers, tape measures, plumb bobs, etc.). Visual Inspection may include Visual Testing, but many forms of Visual Inspection are not included within Visual Testing. Confusion about what is included with Visual

Inspection is the probable reason that Visual Testing was listed less frequently than other non-visual techniques such as ultrasonic testing or penetrant testing.

A separate question asked who typically performed the NDT work—engineers or technicians—and whether the work was ever contracted out. Sixteen DOTs indicated that technicians typically performed the NDT, 2 DOTs indicated that engineers typically performed the NDT, and 17 DOTs indicated that both engineers and technicians performed the NDT. In addition, 20 DOTs indicated that their NDT work was at least partially completed through outside contracts, although it is not clear if these contracts used engineers or technicians.

Two questions touched on the qualifications of the inspectors with regard to the three certification levels defined by ASNT. According to ASNT-TC-1A, the Level III certified individual is involved in policy-level decisions about the use of his specialty area(s) of NDT.[3] Although neither question specifically asked about the use of ASNT Level III personnel, information regarding this certification level can be gleaned from the responses. The results indicate that seven different States used ASNT Level III certified personnel.

Other questions revealed that 9 of the DOTs were doing research on NDT for steel or concrete bridges, while 28 indicated that they were not doing any NDT-related research. Also, 18 of the DOTs felt adequately directed/informed by the FHWA in the use of NDT for bridges. Six respondents felt adequately informed only part of the time and 13 did not feel adequately informed.

Table 1. Caltrans, 1994, NDT Survey: Question 1. NDT methods currently used.[2]

Type	Number of Responses (37 total)
Ultrasonic Testing (UT)	26
Penetrant Testing (PT)	25
Visual Testing (VT)	19
Magnetic Particle Testing (MP)	17
Radiographic Testing (RT)	5
Acoustic Emission (AE)	2
Eddy Current Testing (ET)	1

RENS, ET AL., 1993[4]

In 1993, Rens, et al. completed an international survey, sponsored by the Association of American Railroads, on general NDE use.[4] While there was no specific evaluation of Visual Inspection in this study, the study did generate relevant information regarding the general use of NDE. The survey was sent to a total of 58 State DOTs and industry organizations. The return rate was approximately 90 percent. Table 2 summarizes the findings relative to the general use of NDE in the United States from the study by Rens, et al. Note that the techniques have been re-ordered by rank from the form given by Rens, et al.

Table 2. Rens, et al., 1993, responses to U.S. questionnaire.[4]

Type	Number of Responses (52 total)
Ultrasonic Testing (UT)	36
Magnetic Testing (MT)	21
Dye Penetrant (PT)	13
Rebar Locator (RL)	6
Schmidt Hammer (SH)	6
Radiographic Testing (XR)	6
Eddy Current Testing (ET)	6
Contract out NDE techniques (C)	6
Voltmeter (VM)	4
Do not use NDE techniques (N)	5
Other (O)	7

RENS AND TRANSUE, 1996[5]

In 1996, Rens and Transue performed a follow-up survey to the 1993 Rens, et al. survey.[4-5] The same respondents were targeted, with a response rate of 86 percent. Again, this survey had no specific evaluation of Visual Inspection, only general NDE use. In this survey, questions were developed to determine what information the user seeks from the use of NDE and what bridge components are deemed difficult to evaluate. Seventy percent of the respondents indicated that bridge decks were the most difficult bridge component to evaluate. For concrete structures, approximately 74 percent of the respondents used NDE techniques to determine reinforcement details, while for steel structures, approximately 84 percent of the respondents used NDE to search for crack location and extent.

FHWA NDE VALIDATION CENTER SURVEY

SURVEY PARTICIPATION

Fifty-two surveys were sent to the FHWA State Division Bridge Engineers to be completed in coordination with the State bridge inspection manager. Forty-two responses were received from State DOTs, for a response rate of 81 percent. To gain a more complete understanding of bridge inspection at all levels, and due to the researchers' familiarity with the Iowa county system, the 99 Iowa counties were targeted for a county-level questionnaire. Seventy-two county responses were received, for a response rate of 73 percent. For simplicity, all references to counties, county responses, or county DOTs (or other similar references) will refer to Iowa counties, Iowa county respondents, or Iowa county DOTs (or similar references). Finally, 15 bridge inspection contractors were targeted for the contractor survey, with 6 responses received (40 percent response rate). The combined response rate for the three target groups was 72 percent.

SURVEY DESCRIPTION

The primary questionnaire developed for this study was targeted toward the State DOTs. This State questionnaire was subsequently modified and used for both county and contractor surveys. As the county DOTs are also agencies responsible for bridge inspection and maintenance, only minor modifications were necessary for two of the questions. More significant modifications were required for the contractor questionnaire, with most of these modifications related to the relationship between the consultant and the bridge owner. For reference, the State, county, and contractor questionnaires are presented in Appendix A.

Each questionnaire contained three sections. Section 1 dealt with the composition of the bridge inspection team, Section 2 dealt with the possible impact of administrative requirements on Visual Inspection, and Section 3 dealt with current and future use of NDE techniques. A total of 24 questions were asked in the State and county questionnaires, with 7 questions in Section 1, 11 questions in Section 2, and 6 questions in Section 3. The contractor questionnaire used the same basic format; however, three questions that had no relevance to contractors were removed.

Sample topics for Section 1 included contractor use (and in what situations), the size and experience of the inspection team, and involvement of registered Professional Engineers (PE) as inspectors. Sample topics for Section 2 included inspection unit size, inspector training requirements, suggested policy changes, vision testing requirements, and the number of bridges inspected annually. Sample topics for Section 3 included inspector certifications, overall NDE techniques used (also those used most frequently), NDE techniques no longer used, and areas for possible future research.

SURVEY RESULTS

Results from the questionnaires are presented in a question-by-question format. The questions are repeated as they were given in the State questionnaire. Notes indicating changes for the county and contractor questionnaires are also shown. The motivation behind each question and the response percentages for each question begin each discussion, followed by a summary of the responses. Where appropriate, comments are also included that highlight specific responses.

Section 1 – Composition of Bridge Inspection Team for Visual Inspection

This section outlines the seven questions and responses that address the composition of the bridge inspection team for Visual Inspection. The goal of this series of questions was to assess factors related to the individual inspectors performing bridge inspections.

1.1. ***State DOT:*** **Are your bridge inspections completed by Department of Transportation (DOT) staff or by outside Contractors?** ***(circle one)***
Only DOT staff Only Contractors Both DOT staff and Contractors

County DOT: **Are your bridge inspections completed by County personnel, State personnel, or by Contractors?** ***(circle one)***
County Personnel State Personnel Contractors Blend of three

Contractors: **Not asked.**

The purpose of this question was to determine the distribution of the different types of inspectors used by bridge owners to perform their bridge inspections. A 100 percent response rate was obtained from both the States and the counties. The results are presented in figure 1. The State survey indicates that in more than 90 percent of the cases, both State personnel and contractors

perform inspections (38 responses). Three State DOTs responded that inspections were performed completely in-house, and one State DOT indicated that contractors were used exclusively. Eight State respondents provided additional information beyond what was solicited. Seven of the eight indicated that State personnel were used for the State inspections; however, contractors were used for inspections below the State level. Another State indicated that the different divisions within the State had the authority to determine contractor use, with some divisions using contractors and other divisions using State inspectors.

County DOT responses to this question yielded a different usage distribution. Twenty-four percent of the respondents indicated that only county personnel were used to perform inspections, while 51 percent indicated that contractors were used. The remaining 25 percent indicated that a mix of county, State, and contractor personnel were used. Of those indicating a mix of county, State, and contractor personnel, 14 of 18 further clarified their response to indicate that a specific combination of county and contractor personnel was used.

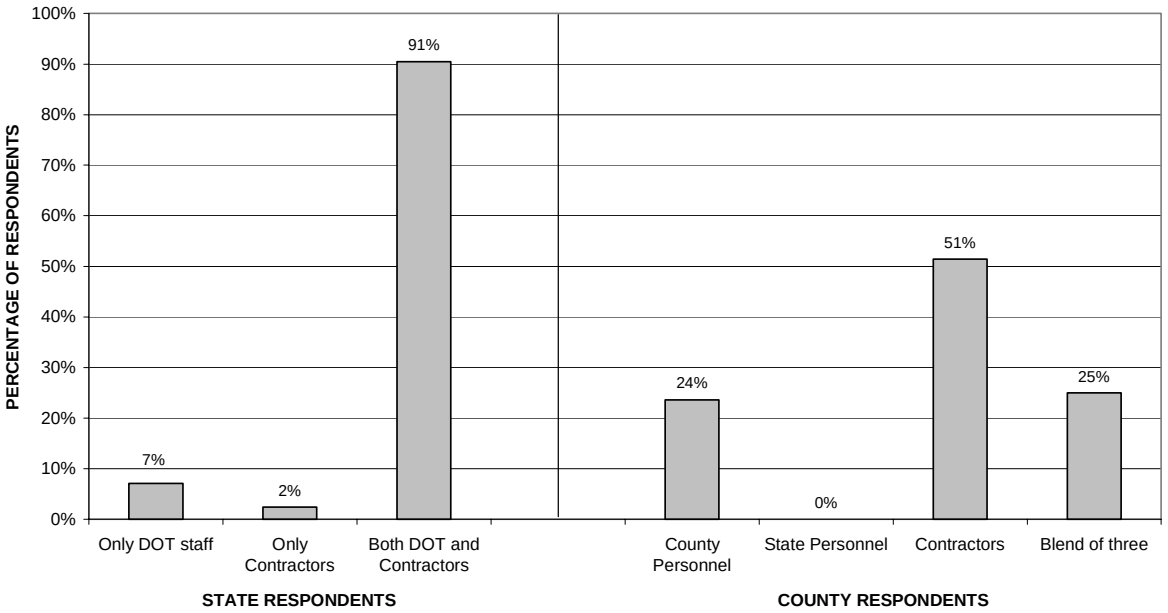


Figure 1. Inspector sourcing.

1.2. ***State DOT:*** **If the answer to Question 1.1 is "Both DOT staff and Contractors," in what situations are Contractors utilized?** ***(mark all that apply)***

County DOT: **If non-county personnel are used for bridge inspections in Question 1.1, in what situations are they involved?** ***(mark all that apply)***

Contractors: **What types of bridge inspection services does your company perform?** ***(mark all that apply)***

Answer choices:

_____ Routine Inspections
_____ Fracture-Critical Inspections
_____ Advanced NDE techniques
_____ Complex structures
_____ Structures with complex traffic control situations
_____ Underwater Inspections
_____ Other ***(please describe below)***

The purpose of this question was to determine what situations lead to the use of a contractor to perform an inspection. All of the State DOT respondents that indicated "Both DOT staff and contractors," also referred to as "partial contractor usage," answered this question, as did all county DOT respondents who indicated "Blend of three," also referred to as "use of outside assistance" or "partial contractor usage." Unfortunately, the wording for the county question was not precise. It was the intent of the question to exclude respondents who used single-source inspections, either all inspections by county staff or all inspections by contractor. To maintain the intent of the question, only responses indicating partial contractor usage in Question 1.1 were considered. Contractors were also asked in what situations their services are utilized, and all six responded to this question.

Figure 2 presents a summary of the inspection types used by State DOTs, county DOTs, and contractors. Eighty-five percent of the State responses indicated that contractors were used for Underwater Inspections. In addition, 59 percent, 54 percent, and 67 percent of the States responded that contractors were used for Routine Inspections, Fracture-Critical Inspections, and complex structures, respectively. Seventy-eight percent of the counties and all of the contractors indicated that contractors were used for Routine Inspections. Fracture-Critical Inspections and complex structures were also listed by 67 percent of the counties and 83 percent of the contractors. Some of the differences between State, county, and contractor respondents include

the use of contractors in complex traffic control situations. Eighty-three percent of the contractors, 39 percent of the States, and 6 percent of the counties indicated that contractors were used to inspect in complex traffic control situations. Another difference observed between State and county responses was that Underwater Inspections were listed as being performed with contractor assistance by about half as many counties (44 percent) as States (85 percent). This may have resulted from the relatively small number of county roads in Iowa that utilize substructures requiring Underwater Inspections. Some of the "Other" write-in responses listed by multiple respondents included: *Contractors used below State level* (seven State respondents), *moveable bridges* (two State respondents), *ultrasonic testing of hanger pins* (two State respondents), *when behind schedule* (two State respondents), and *scour analysis* (two County respondents).

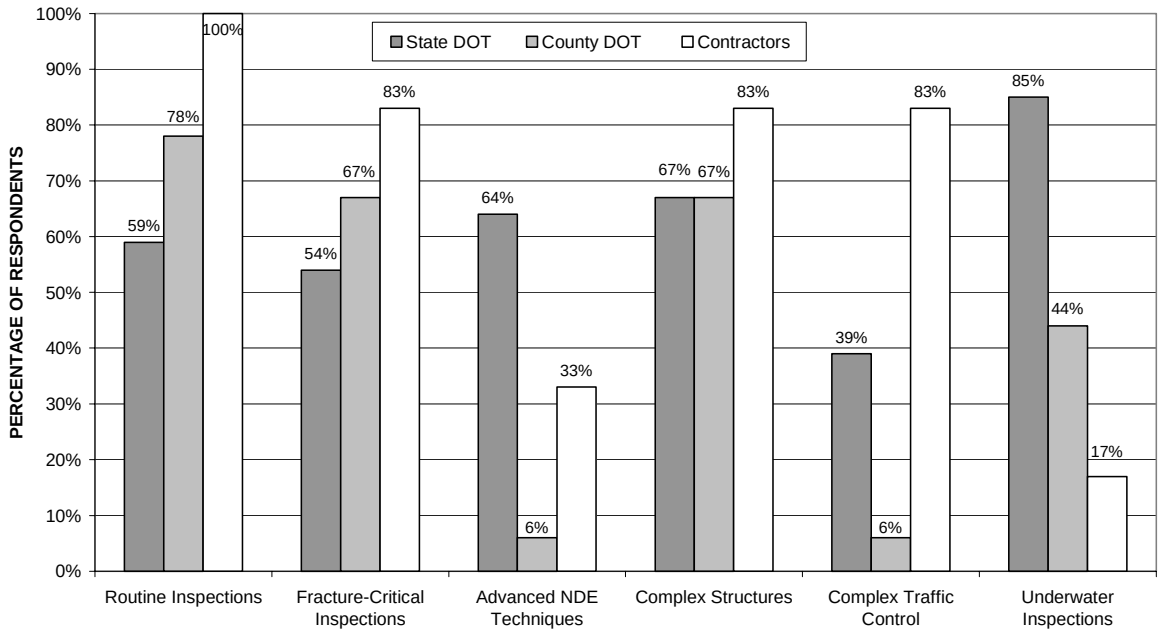


Figure 2. Inspection situations where partial contractor services are used.

1.3. ***State DOT, County DOT, and Contractors:*** **For the following hypothetical bridge, how many people would make up a field inspection team (excluding traffic control personnel), and how much time (in man-hours) would be budgeted?**

Twenty-year-old, two-span bridge carrying two-lane road (medium ADT) over a small creek, maximum height above the creek is 20 ft.
***Superstructure*: Steel, four-girder superstructure (rolled shapes); welded flange cover plates; concrete deck.**
***Substructure*: Concrete abutments, a single three-column concrete pier (with pier cap) out of the normal watercourse.**

People: _____
Man-hours: _____

The purpose of this question was to compare manpower levels and time budgets for a sample bridge inspection. All State respondents and 90 percent of the county respondents answered this question. The average response for manpower level ranged from 1.8 to 2.2 people. The average State and county time budgets were 4.8 and 4.2 man-hours, respectively. The average contractor time budget was 22.3 man-hours, however, this estimate probably includes report preparation time that was probably not included in the State and county estimates. A summary of the responses is provided in table 3. Note that this table also includes the reported ranges and standard deviations of responses, illustrating the organizational differences between individual DOTs.

Table 3. Staff budget and man-hours for bridge described in Question 1.3.

	People			Man-Hours		
	Average	Standard Deviation	Range	Average	Standard Deviation	Range
State DOT	2.0	0.57	1-4	4.8	3.7	0.5-16
County DOT	1.8	0.69	1-4	4.2	6.1	0.5-32
Contractors	2.2	0.41	2-3	22.3	19.4	4.0-48

1.4. ***State DOT, County DOT, and Contractors:*** **What are the minimum, maximum, and typical number of personnel that would make up a bridge inspection team (excluding traffic control personnel)?**

Minimum: _____
Maximum: _____
Typical: _____

The purpose of this question was to determine information about the size of the inspection team. All State and contractor respondents and 93 percent of the county respondents answered this question. The State responses ranged from 1 to 13 inspectors. County responses ranged from one to five inspectors and contractors ranged from two to six inspectors. Five State respondents and 22 county respondents indicated that their bridge inspection teams would consist of only 1 person. The average "Typical" response from the State DOTs was 2.0 people. The average "Typical" response from the counties was 1.7 people, and from the contractors, it was 2.5 people. A summary of the responses is presented in table 4.

Table 4. Minimum, maximum, and typical number of personnel on a bridge inspection team.

	Minimum	Average Minimum	Average Typical	Average Maximum	Maximum
State DOT	1	1.6	2.0	3.9	13
County DOT	1	1.4	1.7	2.7	5
Contractors	2	2.2	2.5	5.5	6

1.5. ***State DOT, County DOT, and Contractors:*** **Estimate the percentage of bridge inspections completed with a registered Professional Engineer (PE) on-site?** ***(circle one)***

0-20% 21-40% 41-60% 61-80% 81-100%

The purpose of this question was to determine the frequency of the presence of a registered PE on site during bridge inspections. All State and contractor respondents and 96 percent of the county respondents answered this question. As shown in figure 3, responses were clustered near the extremes of 0 to 20 percent and 81 to 100 percent. About 50 percent of the States and counties indicated that a PE was on site for between 0 to 20 percent of the inspections. Alternatively, about 25 percent of the States and 30 percent of the counties indicated that PEs were used on site for between 61 and 100 percent of the inspections. A much higher percentage of contractors (83 percent) indicated the use of PEs on site between 81 and 100 percent of the time.

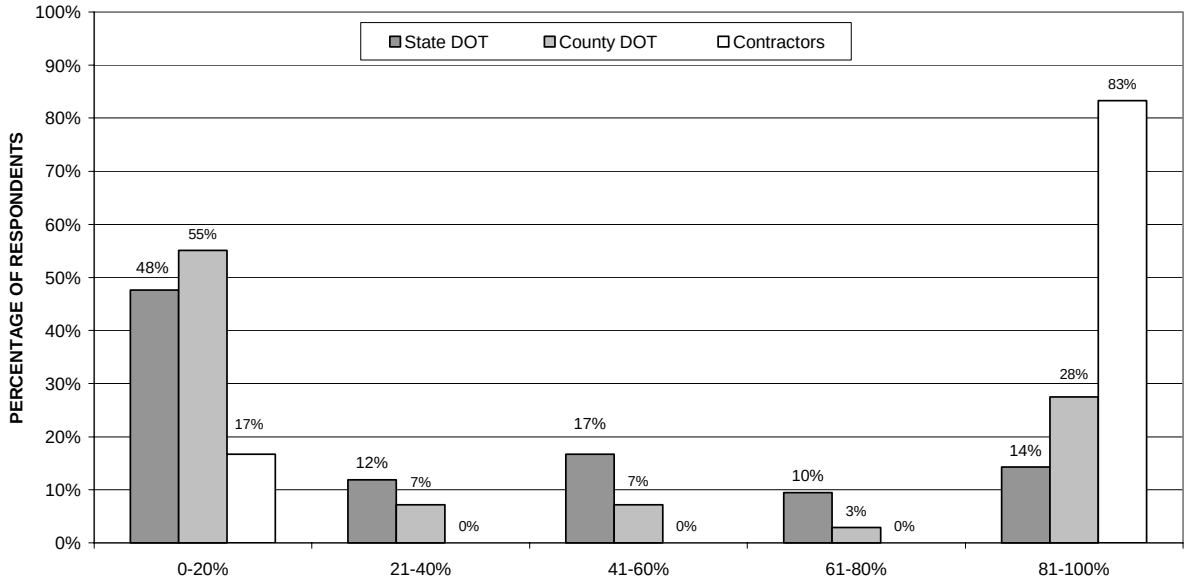


Figure 3. Inspections completed with PE on site.

1.6. *State DOT, County DOT, and Contractors:* When a PE is included as part of the on-site inspection team, what conditions would dictate his/her presence?

The purpose of this question was to determine under what conditions PEs were used on site during bridge inspections. Forty-one State respondents, 60 county respondents, and all 6 contractors answered this question. Due to the variability of the 107 write-in responses, some response fitting was used to present the responses in a series of 10 categories. The grouped responses are summarized in table 5. For State and contractor respondents, the most frequently cited condition for having a PE on-site was that this was a normal part of the bridge inspection team (17 responses). In categorizing this data, many responses included comments indicating that PEs were part of the inspection teams by coincidence, thus implying that some inspection teams in those 17 States may not have PE members. The most frequently indicated response for the county respondents and the second most frequently indicated response for the State respondents was that the PE is present to follow-up a previous Routine Inspection that indicated the need for an assessment of specific damage or deterioration.

Table 5. Situations causing on-site PE presence.

		State DOT	County DOT	Contractors
A.	PE is normal member of inspection team	17	11	5
B.	Follow-up from previous Routine Inspection (assess damage/deterioration)	14	26	—
C.	Random presence/no special reason given	7	7	—
D.	Fracture-Critical Inspection	4	10	—
E.	Complex structures	4	5	1
F.	Underwater Inspection/Scour Inspection	4	5	—
G.	Critical-condition structure (poor condition, road closure considered)	3	13	—
H.	Complex NDE	3	—	—
I.	Workload permitting/inspections behind schedule	2	2	1
J.	Inspection complexity	—	1	1

1.7. ***State DOT, County DOT, and Contractors:*** **Please indicate the average number of years of experience in bridge inspection at each of the following positions.** ***(circle the appropriate responses)***

Team leader:

0-5 years & PE **5-10 years** **More than 10 years**

Other team members:

0-5 years **5-10 years** **More than 10 years**

The purpose of this question was to determine the typical experience level of bridge inspectors. All State and contractor respondents and 92 percent of the county respondents answered this question. Figure 4 shows the distribution for both team leaders and other team members. As expected, team leaders generally have more experience than other team members. Approximately 10 percent of the State and county respondents indicated that their team leaders had an average of 0 to 5 years of experience and a PE license. Three States indicated that, on average, the other team members had more experience than the team leaders. Contractor responses were generally similar to State and county responses except that all contractor responses indicated that the other team members had less than 5 years of experience.

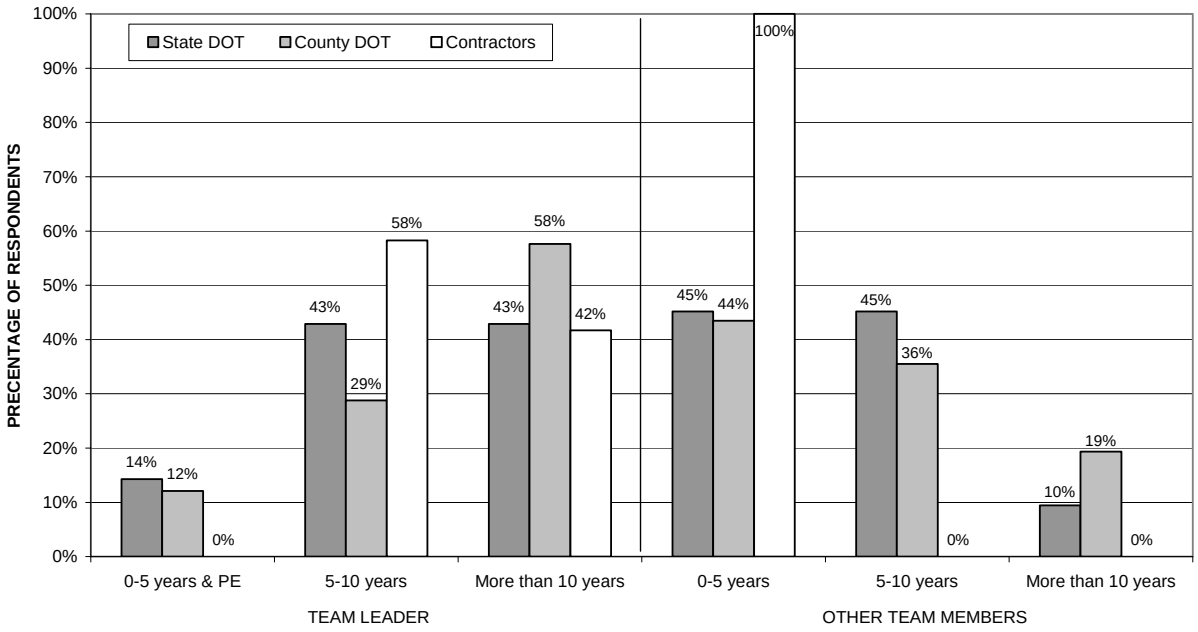


Figure 4. Years of experience for bridge inspectors.

Section 2 – Impact of Administrative Requirements on Visual Inspection

The following section outlines the 11 questions and responses from Section 2 that assess the impact of administrative requirements on Visual Inspection. The purpose of this series of questions was to assess how management decisions affect bridge inspections.

2.1. ***State DOT and County DOT:*** **If additional resources were made available for bridge inspection, please indicate how you might allocate those additional resources (for example, increased time per inspection, increased use of NDE methods, increased use of bridge inventory management software, etc.).**

Contractors: **Not asked**

The purpose of this question was to qualitatively identify the most critical need not being met by current bridge inspection programs. All State respondents and 58 county respondents answered this question. Table 6 summarizes findings from this question. As shown in the table, increased use of NDE and increased personnel were the most frequently cited need areas for additional

resources by State respondents, with 15 responses each. The question may have been slightly leading by presenting three sample responses. For example, one of the sample responses, increased use of NDE methods, tied for the most frequent response. The other State response listed most frequently, increased personnel, was not presented as a sample response, indicating its relative importance. Similarly, additional equipment (also not a sample response) was the second most frequently cited need by State respondents, and of these 14 responses, 9 specifically mentioned "snooper" inspection vehicles.

Table 6. Allocation for additional resources.

	State DOT	County DOT
Increase use of NDE	15	20
Increase personnel	15	6
Increase equipment	14	4
Improvements to Bridge Management System	12	23
Increase time per inspection	10	17
Increase training	5	1
Maintenance improvements	2	—
Remote bridge monitoring	2	2
Improve QA/QC	2	—
Perform inspections in-house	2	—
Inspect "bridges" shorter than 20 ft	—	1
Increase scope of scour surveys	—	1
Improve repair recommendations	—	1

2.2. ***State DOT, County DOT, and Contractors:*** **Approximately how many bridge inspectors are in your bridge inspection unit?** ***(circle one)***
1-5 6-10 11-15 16-20 21-25 26-30 31-40 41-50 More than 50

The purpose of this question was to determine the size of the inspection units. All State and contractor respondents, and 67 county respondents answered this question. As shown in figure 5, the size of the inspection units varies considerably between the three organizational types. County respondents were generally clustered at the smaller end of the scale (mostly 1-10), while contractors were only slightly larger (1-20). Surprisingly, two county respondents indicated that their inspection units had more than 50 inspectors. State respondents indicated that the sizes of

their inspection units were more uniformly distributed, with nearly as many small units as large units. These distributions make intuitive sense. The Iowa counties have land areas that are generally similar in size and terrain. Consequently, Iowa counties have inspection units of approximately similar sizes. On the other hand, the land areas of the States vary considerably, as does the local terrain, requiring different sizes of inspection units.

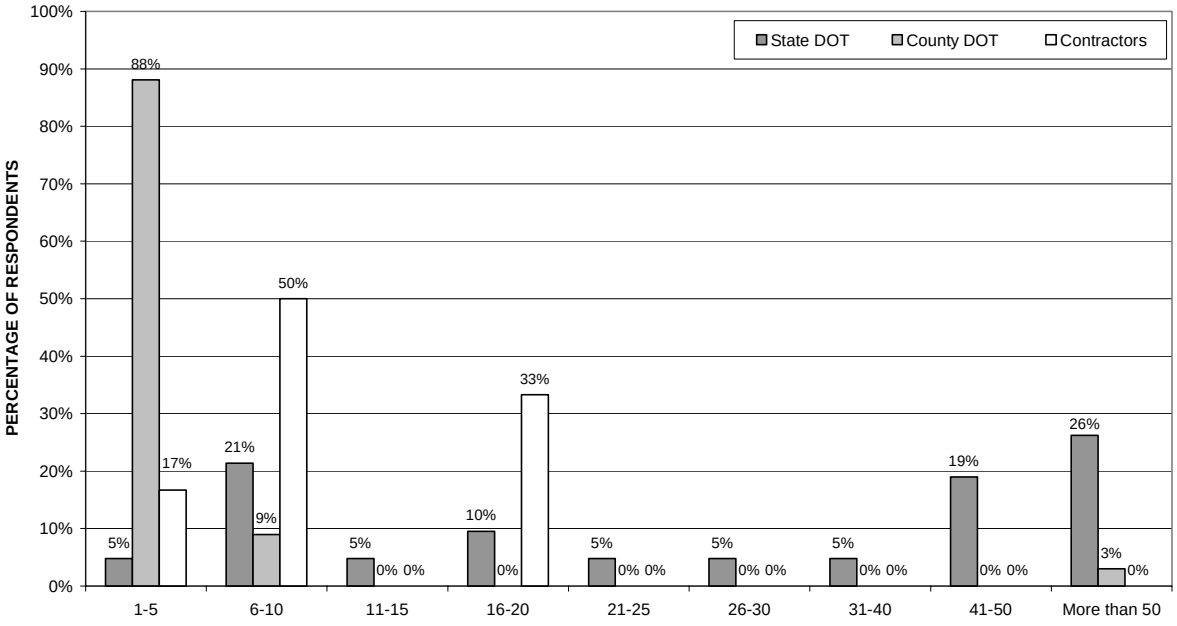


Figure 5. Number of bridge inspectors in inspection units.

2.3. ***State DOT, County DOT, and Contractors:*** **What type of training do you require of bridge inspectors?** ***(mark all that apply)***

Team leaders:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Bridge Inspector's Training Course
_____ Fracture-Critical Inspection Course
_____ Stream Stability Course
_____ Other Training Courses *(please specify)*

Other team members:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Bridge Inspector's Training Course
_____ Fracture-Critical Inspection Course
_____ Stream Stability Course
_____ Other Training Courses *(please specify)*

The purpose of this question was to quantify the required types of training for bridge inspectors. Figures 6 and 7 illustrate the distribution of training requirements for the three participant groups. All 42 State respondents, 65 of the county respondents, and all 6 contractors answered this question. As shown in the figures, the most frequently required form of training was the Bridge Inspector's Training Course, required by more than 90 percent of the State and county respondents. In addition, there were more training requirements imposed on team leaders than on other team members. Further discussion of training and certification is made in Question 3.2.

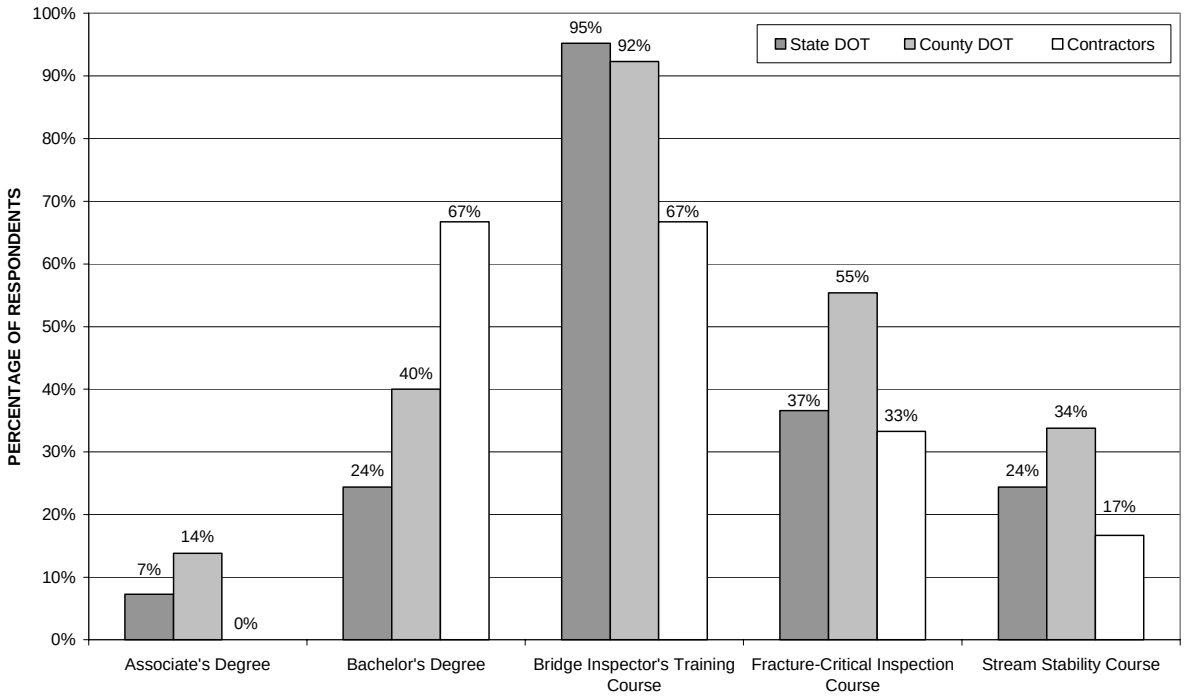


Figure 6. Required training – Team leaders.

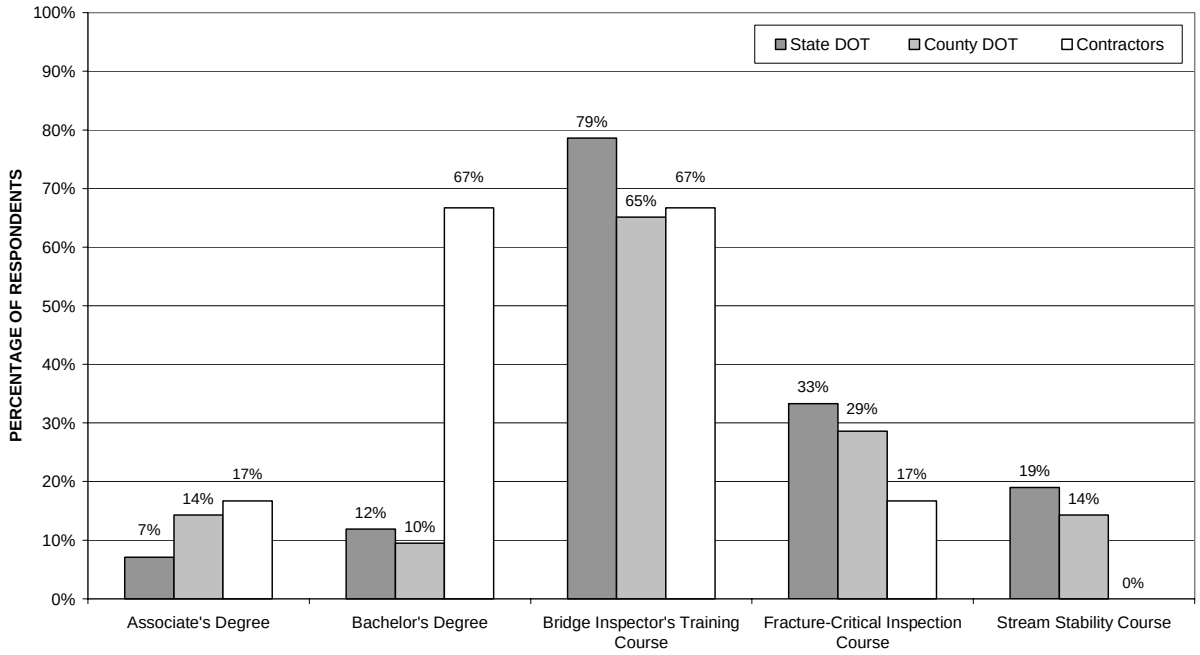


Figure 7. Required training – Other team members.

2.4. ***State DOT, County DOT, and Contractors:*** **Could you suggest any changes in administrative or inspection procedure or policy that may improve inspection performance? Explain.**

End-users can often provide valuable insight into how to improve the job they are performing. Therefore, the purpose of this question was to solicit improvements to administrative or inspection procedures or policies. Thirty-three State respondents, 28 county respondents, and 3 contractors answered this question. The write-in format of this question resulted in a wide variety of responses. Only two topics received more than two responses from any of the target groups. Six of the State respondents suggested the expansion of the bridge management system to include the direct electronic incorporation of field data. Five county respondents suggested that additional resources from the Federal government in the form of funding for contract inspectors, personnel, training, and software would improve their inspection process. Table 7 summarizes the compiled list of suggestions from State and county respondents, with the associated tally of responses.

Table 7. Suggested changes in administrative or inspection procedures or policies.

	State DOT	County DOT
Bridge Management System (BMS) Issues		
Electronic data from inspections w/direct input into BMS	6	—
Require element-level inspection data	1	—
Post bridge repair list on Internet	1	—
Devote more time to inspection and inventory management	—	2
Training/Continuing Education Related		
Continuing education requirements for team leaders	2	—
Monitor and audit content of NHI course	1	—
Require Bridge Insp. Training Course for other team members	1	—
Hold single-day refresher course more frequently	—	1
Standardize continuing education requirements	—	1
Inspection Operation/Procedure Improvements		
Better access for inspection in urban areas	2	—
Additional field time by bridge maintenance engineers	1	—
Improved procedures for inspection of prestressed concrete	1	—
Fully documented procedures in a Bridge Inspection Policy Manual	1	—
Regulations for scour (not guidelines)	1	—
4- to 5-year cycle for Fracture-Critical Members and Special Inspection of major bridges	1	—
Statewide Quality Control	1	—
Summertime inspections	1	—
Mandatory inspections for timber bridges more than 30 years old	—	1
Structure Inventory and Appraisal (SI&A) form changes too quickly, keep same form for a minimum of 3 to 4 years	—	1
More equipment to check scour conditions	—	1
Miscellaneous		
Pay consultants on a unit basis, not hourly basis	1	—
More Federal money (contract inspections, more personnel, training, and software)	—	5

2.5. ***State DOT, County DOT, and Contractors:*** **Do you test the vision of inspectors (with corrective lenses if necessary)?** ***(circle one)***

Yes No

Research related to the reliability of Visual Inspection in other fields, including the Nuclear Power Industry and the Aviation Industry, indicated that some industries have certification programs for their inspectors. One component of these certification procedures often includes a vision test. This question attempted to determine whether any highway agencies are using similar methods to certify the vision of their inspectors. All State and contractor respondents, along with 66 county respondents, answered this question. None of the contractors indicated that they test the vision of their employees. Of the 66 county responses, 2 counties indicated that they test the vision of their inspectors. No information was provided as to what kind of vision test was used. Forty States indicated that they do not test the vision of their inspectors, while two States indicated that they did test the vision of their inspectors. These two States volunteered that the vision test requirement was part of a motor vehicle license test. From other questions, it was also learned that two other States had certification programs for their inspectors, but specific details on these programs were not provided beyond the negative response to the vision testing question.

2.6. ***State DOT, County DOT, and Contractors:*** **For a given bridge, are copies of previous inspection reports made available to the inspectors prior to arriving at the bridge site?** ***(circle one)***

Yes No

2.7. ***State DOT, County DOT, and Contractors:*** **Are inspectors permitted to use copies of previous inspection reports at the bridge site?** ***(circle one)***

Yes No

The purpose of these two related questions was to gauge the use of previously completed inspection reports. Forty-one of the 42 State respondents, 67 of the 72 county respondents, and all 6 contractors answered these two questions. All respondents indicated that copies of previous inspection reports were made available both before arrival at the bridge site and at the bridge site. One State indicated that it allows previous inspection reports to be used in the field, but does not recommend this practice.

2.8. ***State DOT, County DOT, and Contractors:*** **Who determines the order of field inspection tasks?** ***(mark the most appropriate response)***

_____ "Management" provides a checklist to the on-site team to organize the inspection process.

_____ Individual inspectors on-site set the inspection process.

The purpose of this question was to determine the amount of latitude individual inspectors have in relation to the on-site inspection process. All State and contractor respondents answered this question, and 65 of the 72 county respondents answered the question. Ninety-one percent of the State respondents indicated that individual inspectors set the inspection process, while only 9 percent indicated that a checklist of tasks was provided by "management." Similarly, 65 percent of the county respondents indicated that the individual sets the process, while 35 percent indicated that a checklist was provided. Eighty-three percent of the contractors indicated that individuals set the inspection process.

2.9. ***State DOT, County DOT, and Contractors:*** **Approximately how many bridges are inspected by your organization *each year*?**

The NBIS generally requires inspections be completed at least every 2 years.[1] Due to suspect conditions, this interval is sometimes reduced. Therefore, it was desirable to determine how many bridges are inspected each year. Forty-one State DOTs, 68 county DOTs, and all 6 contractors answered this question. Table 8 presents a summary of average, minimum, maximum, and total responses. The indicated total number of bridges inspected by the States each year of 250,000 appears reasonable. This number is approximately half of the accepted total number of bridges, which is in excess of 500,000. Since 79 percent of the 52 FHWA Divisions responded, it would be expected that this total would exceed 200,000 bridges per year (79 percent of the total number of bridges, multiplied by the number of inspections at each bridge per year). One possible reason for the 50,000 extra bridges per year is due to increased inspection frequency. Alternatively, the county total is slightly suspect, since it is anticipated that there are only about 20,000 secondary road bridges in Iowa.[6] With the number of responses, and a typical inspection frequency of once every other year, it would be expected that the total response would have been just over 7,000. No States gave any indication that all

inspections were performed every other year. Five of the county respondents did indicate that they had all their bridges inspected every other year.

Table 8. Bridges inspected each year.

	Average	Minimum	Maximum	Total
State DOT	6,300	120	30,000	250,000
County DOT	240	0*	3,500	17,000
Contractors	820	30	2,500	3,800

*Bridges inspected in alternate years.

2.10. ***State DOT, County DOT, and Contractors:*** **What measures do you have in place to assure quality inspections?**

The purpose of this question was to compare the quality assurance/quality control (QA/QC) measures used. Forty of the State respondents, 56 of the county respondents, and all 6 contractors answered this question. Again, some response fitting was necessary to compile these responses, and the 20 broad categories presented in table 9 summarize all of the responses. Note that many responses included multiple items, and each listed item was categorized as a separate response. This multiple listing results in a tally larger than the number of respondents. The two most frequent quality measures used by the States were an office review of the inspection reports (19 QC responses) and an independent field re-inspection program (15 QA responses). Two of the more novel QA/QC program responses included a rotation program, so that inspectors are alternated for subsequent inspections at each bridge, and a rating comparison/validation program where all inspectors within the State rate the same group of bridges to ensure consistency.

2.11. ***State DOT and County DOT:*** **Please describe any recent accomplishments of your bridge inspection program (for example, an innovative inspector training program, successful implementation of new NDE technologies, identification of potentially life-threatening conditions, etc.).**

Contractors: **Not asked.**

Table 9. Quality measures.

	State DOT	County DOT	Contractors
Quality Control Measures			
Office review of inspection reports	19	9	3
Rotation of inspectors	5	3	1
QA/QC program (no specific details)	4	—	1
Hand-search database for irregularities	2	—	—
Require use of inspection manuals and checklists	1	7	2
Training courses	1	7	—
Photographs and written documentation required to change condition rating	1	—	—
Hire consultant to perform inspections	—	10	—
Hire quality employees	—	5	—
Bridge Engineer also performs inspections	—	2	—
Qualified/Certified inspectors	—	1	2
Continuing education	—	1	—
Hire inspectors without fear of heights	—	—	1
Good communications between client/consultant	—	—	1
Quality Assurance Measures			
Field re-inspection program to spot-check team's reports	15	11	2
Occasional PE "ride-alongs" and field review of inspection teams	11	—	—
Annual review by FHWA for NBIS compliance	6	—	—
Internal NBIS compliance reviews	5	—	—
Regular staff meetings	5	—	—
QA/QC program (no specific details)	4	—	1
All inspectors inspect common bridge and discuss results	1	—	—

The purpose of this question was to share recent accomplishments of the participants' bridge inspection programs. Thirty-three State and 20 county respondents answered this question. Due to the significant variability of responses, complete responses are compiled in Appendix B. Entries in Appendix B are nearly complete, but name references have been changed to preserve anonymity, and responses such as "N/A" or "None" have been omitted. Table 10 summarizes responses grouped into 14 categories. Most of the responses dealt with information management

or bridge management systems (11 responses from each of the State and county respondents). Descriptions of emergency conditions that had been identified and addressed were the second most frequently noted accomplishment.

Table 10. Accomplishments of Bridge Inspection Programs.

	State DOT	County DOT
Bridge Management System-type accomplishments (Implementation of Pontis-type system, spreadsheet and database applications, electronic field data incorporation, Internet applications of repair lists)	11	11
Emergency conditions found and addressed	7	4
Scour surveys	4	2
Training courses/Inspector certification program	4	1
Hanger pin replacement program/NDT of hanger pins	4	—
NDT used for clearance, scour, and depth	3	—
Pile capacity testing/NDT for pile length	2	—
Proof testing of load-rated bridges	2	—
Climbing techniques implemented	2	—
Bridge Inspection Handbook/Guidelines	2	—
QA/QC program	2	—
New equipment	2	—
Analysis to confirm fracture-critical members	1	—
Back on 2-year cycle	1	—

Section 3 – Current and Future Use of NDE Techniques

This section outlines the six questions and responses dealing with the current and future use of NDE techniques. This section was included to gather general data on NDE use and the need for future research.

3.1. ***State DOT, County DOT, and Contractors:*** **Do you have any American Society for Nondestructive Testing (ASNT) Level III inspectors on staff?** ***(circle one)***

Yes No

If so, what method(s) are they certified for? ***(check all those that apply)***

_____ Acoustic Emission (AE)
_____ Electromagnetic Testing (ET)
_____ Leak Testing (LT)
_____ Liquid Penetrant Testing (PT)

_____ Magnetic Particle Testing (MT)
_____ Neutron Radiographic Testing (NRT)
_____ Radiographic Testing (RT)
_____ Thermal/Infrared Testing (TIR)
_____ Ultrasonic Testing (UT)
_____ Vibration Analysis Testing (VA)
_____ Visual Testing (VT)

If applicable, are these ASNT Level III Inspectors routinely used in field situations? ***(circle one)***

Yes No

According to ASNT-TC-1A, a Level III certified individual is involved in policy-level decisions about the use of his specialty area(s) of NDT.[3] The purpose of this question was to determine the use of this certification program for the bridge inspection area. In addition, it was desirable to know how a Level III certified inspector was used during bridge inspections. All State and contractor respondents, and 66 of the county respondents, answered this question. For the county or contractor respondents, no ASNT Level III inspectors were on staff. Fourteen of the 42 State respondents indicated that they had ASNT Level III inspectors on staff. Table 11 presents a breakdown of the disciplines in which the Level III inspectors were certified. Three disciplines had response percentages greater than 70 percent: Liquid Penetrant Testing (79 percent), Ultrasonic Testing (79 percent), and Magnetic Particle Testing (71 percent). All 14 of the affirmative responses indicated that the Level III inspectors were used in field situations.

Recall that the 1994 Caltrans survey contained some information relevant to ASNT Level III personnel.[2] Specifically, recall that 7 of the 37 Caltrans respondents indicated that Level III personnel were used. This number can be compared with the usage determined from this survey, where 14 of the 42 respondents indicated that Level III personnel were used. In percentage terms, this is an increase from 19 percent to 33 percent of respondents, indicating that the use of the ASNT Level III certification program has increased.

Table 11. ASNT Level III by types.

	State DOT Responses
Liquid Penetrant Testing (PT)	11
Ultrasonic Testing (UT)	11
Magnetic Particle Testing (MT)	10
Visual Testing (VT)	7
Radiographic Testing (RT)	5
Electromagnetic Testing (ET)	1
Acoustic Emission (AE)	0
Leak Testing (LT)	0
Neutron Radiographic Testing (NRT)	0
Thermal/Infrared Testing (TIR)	0
Vibration Analysis Testing (VA)	0

3.2. ***State DOT, County DOT, and Contractors:*** **Mark any certifications which the typical Bridge Inspection Team Member may hold?** ***(Mark all that apply. Note that NICET refers to the National Institute for Certification in Engineering Technologies Bridge Safety Inspection.)***

Team leader	**Other team members**
____ PE License	**____ PE License**
____ ASNT Level I	**____ ASNT Level I**
____ ASNT Level II	**____ ASNT Level II**
____ ASNT Level III	**____ ASNT Level III**
____ NICET Level I	**____ NICET Level I**
____ NICET Level II	**____ NICET Level II**
____ NICET Level III	**____ NICET Level III**
____ NICET Level IV	**____ NICET Level IV**
____ Other _____	**____ Other _____**

The purpose of this question was to gauge typical certification programs used by inspection units. Thirty-nine State, 47 county, and all contractor respondents answered this question. As shown in figures 8 and 9, the PE license was the most commonly indicated certification held by either team leaders or other team members. More than 70 percent of the State respondents, 67 percent of the county respondents, and all contractor respondents indicated that the team leader might hold a PE license. The PE license was also commonly indicated for the other team members, with a minimum positive response of 22 percent (State). The results of this question

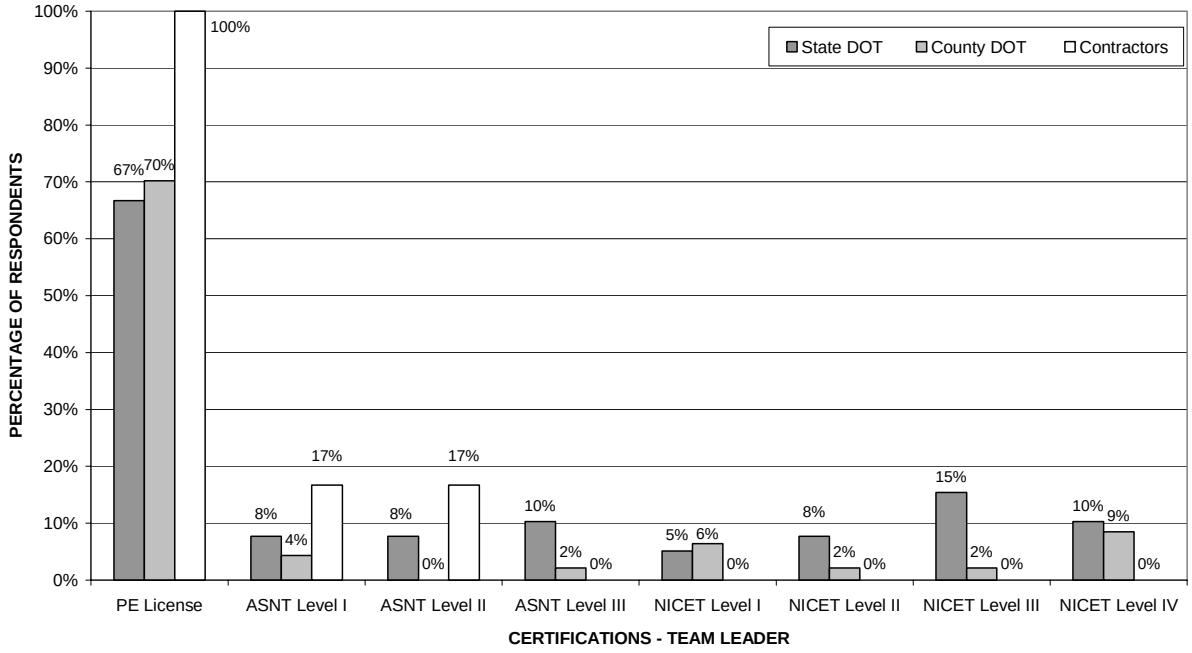


Figure 8. Team leader certifications.

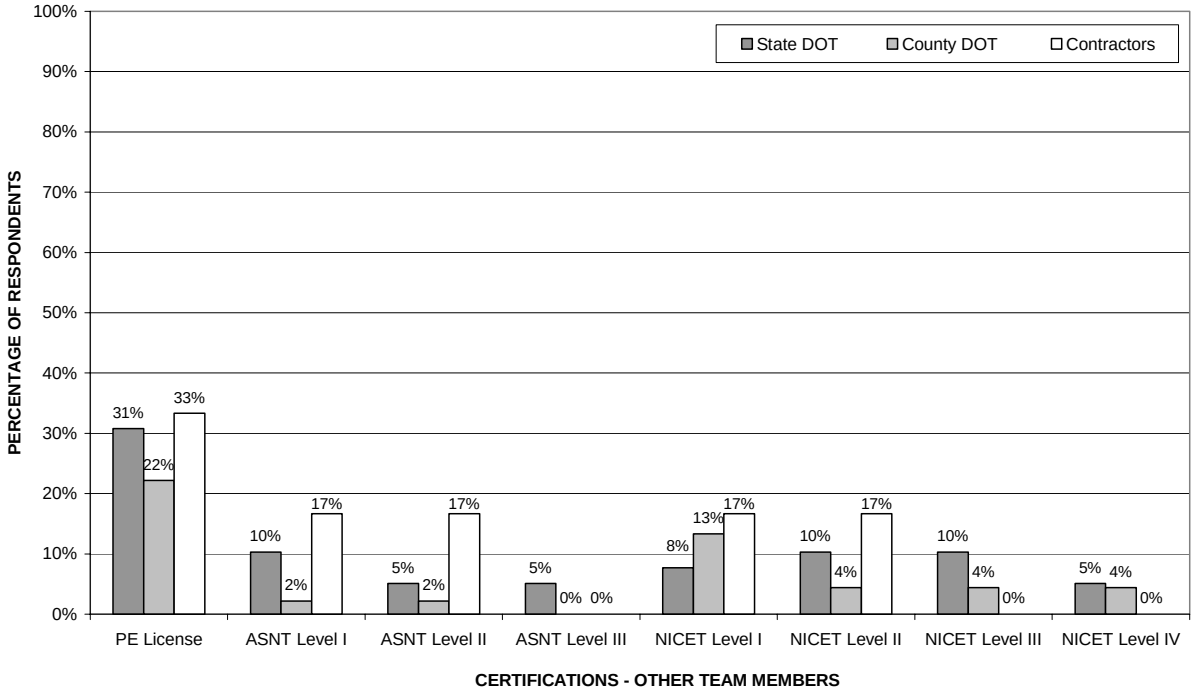


Figure 9. Other team member certifications.

also indicate that the NICET certification program has a low level of utilization. The highest positive response for any NICET certification from State respondents was 15 percent (NICET Level III, team leader). For county respondents, the highest NICET certification level was 13 percent (NICET Level I, other team members).

The data clearly show the relative prevalence with which the Bridge Inspector's Training Course is used to satisfy NBIS requirements for inspection teams. The three NBIS methods for qualification as team leader are any of: (1) a PE license, (2) 5 years of experience and completion of the Bridge Inspector's Training Course, or (3) NICET certification as a Level III or IV Bridge Safety Inspector.[1] From Question 2.3, more than 90 percent of both States and counties indicated that the Bridge Inspector's Training Course was required for team leaders. Similarly, about two-thirds of the contractors indicated that they require their team leaders to complete the Bridge Inspector's Training Course. The requirement for the Bridge Inspector's Training Course for other team members was almost as high, with a minimum response of 65 percent. In comparison, when asked in Question 3.2 about typical certifications that team leaders may have, only 15 percent of the States indicated NICET Level III, with an additional 10 percent indicating NICET Level IV certification.

3.3. ***State DOT, County DOT, and Contractors:*** **What NDE techniques are currently utilized on bridges under your jurisdiction?** ***(mark all that apply)***

Steel:

Acoustic Emission	**Eddy Current**
Other Electromagnetic Testing	**Liquid Penetrant**
Magnetic Particle	**Radiography**
Thermal/Infrared	**Ultrasonic**
Vibration Analysis	**Visual Inspection**
Other	

Concrete:

Acoustic Emission	**Cover Meters/Pachometers**
Electrical Potential Measurements	**Mechanical Sounding (Chain Drag)**
Radar	**Radiography**
Rebound Hammer	**Thermal/Infrared**
Ultrasonics (Pulse Velocity)	**Ultrasonics (Impact-Echo)**
Vibration Analysis	**Visual Inspection**
Other	

Timber:

Acoustic Emission **Mechanical Sounding**
Moisture Meter **Radiography**
Stress Wave Analysis **Visual Inspection**
Other

Other Materials:

Material/Technique
1)
2)
3)

The purpose of this question was to determine which NDE techniques are currently being used for bridge inspections. All of the State respondents, 49 of the county respondents, and all of the contractors answered this question. The results are presented in two formats. First, all of the data will be presented in three material-specific tables. These material-specific tables are presented as tables 12 through 14. A fourth table, table 15, shows the techniques that are used for more than one material, to allow for easy comparison. No respondents from any group provided responses for the Other Materials category question.

Visual Inspection was indicated as a technique used by the largest number of respondents for each of the three materials. There were some relatively new applications (to bridge inspections) of existing NDE technology cited by respondents. Examples include acoustic emission for steel (five States and one county) and concrete materials (one State and one county), radar for concrete materials (nine States), and thermal/infrared for concrete materials (five States and one county). The use of these advanced techniques at both the State and county levels indicates a willingness by at least some of the DOT agencies to try new technologies to improve bridge inspections.

Comparisons of NDE Use can also be made against the 1993 Rens, et al. survey and the 1994 Caltrans survey.[2,4] Five respondents in the 1993 Rens, et al. survey indicated that they did not use NDE techniques. Recall that the Rens, et al. sample included State DOT and industry organizations, so it is unclear whether these five respondents were DOTs or industry organizations. All State respondents in the Caltrans and NDEVC surveys indicated that some form of NDE was used. Comparisons can also be made regarding the use of specific NDE

techniques for which data are available from all three surveys. Five techniques are common to all three surveys: Ultrasonic testing, magnetic particle testing, penetrant testing, radiographic testing, and eddy current testing. Table 16 presents usage rates in percentage terms for comparison between the three surveys. For each of the five techniques, usage rates have increased, with the largest increases being reported for magnetic particle testing, liquid penetrant testing, and ultrasonic testing.

Table 12. Steel NDE techniques used.

Steel NDE Technique	State DOT	County DOT	Contractors
Visual Inspection	40	46	6
Liquid Penetrant	34	2	4
Ultrasonics	34	0	4
Magnetic Particle	27	0	4
Radiography	7	0	1
Acoustic Emission	5	1	2
Vibration Analysis	4	2	1
Eddy Current	4	0	0
Other Electromagnetic Techniques for Steel	1	0	0
Mechanical Sounding*	—	1	—
Thermal/Infrared	0	0	0
Other: Sonic Force*	1	—	—
Other: D-meter*	—	—	1

*Write-in response.

Table 13. Concrete NDE techniques used.

Concrete NDE Technique	State DOT	County DOT	Contractors
Visual Inspection	38	46	6
Mechanical Sounding	32	31	4
Cover Meter	21	0	2
Rebound Hammer	19	9	2
Electrical Potential Measurements	11	0	2
Radar	9	0	1
Ultrasonics (impact-echo)	8	0	1
Thermal/Infrared	5	1	1
Acoustic Emission	1	1	0
Vibration Analysis	0	1	0
Radiography	0	0	0
Ultrasonics (pulse velocity)	0	0	0

Table 14. Timber NDE techniques used.

Timber NDE Technique	State DOT	County DOT	Contractors
Visual Inspection	36	46	5
Mechanical Sounding	35	19	3
Moisture Meter	5	1	1
Stress Wave Analysis	2	0	0
Acoustic Emission	0	0	0
Radiography	0	0	0
Other: Boring/Coring*	4	2	—
Other: Inspection Pick*	2	1	10
Other: Timber Decay Detecting Drill*	2	—	—

*Write-in response.

Table 15. Comparison of NDE techniques used on multiple materials.

NDE Technique	State DOT	County DOT	Contractors
Acoustic Emission			
Steel	5	1	2
Concrete	1	1	0
Timber	0	0	0
Mechanical Sounding			
Steel*	—	1	—
Concrete	32	31	4
Timber	35	19	3
Radiography			
Steel	7	0	1
Concrete	0	0	0
Timber	0	0	0
Thermal/Infrared			
Steel	0	0	0
Concrete	5	1	1
Ultrasonics			
Steel	34	0	4
Concrete (pulse velocity)	0	0	0
Concrete (impact-echo)	8	0	1
Vibration Analysis			
Steel	4	2	1
Concrete	0	1	0
Visual Inspection			
Steel	40	46	6
Concrete	38	46	6
Timber	36	46	5

*Write-in response.

Table 16. Percentage of respondents indicating the use of specific NDE techniques.

NDE Technique	NDEVC, 1998	Caltrans, 1994[2]	Rens, et al., 1993[4]
Ultrasonic Testing	81%	70%	69%
Liquid Penetrant Testing	81%	68%	25%
Magnetic Particle Testing	64%	46%	40%
Radiographic Testing	17%	14%	12%
Eddy Current Testing	13%	3%	12%

3.4. ***State DOT, County DOT, and Contractors:*** **Of these NDE techniques, which method do you use most often for each material?**

Steel:
Concrete:
Timber:
Other Materials:

The purpose of this question was to refine Question 3.3 to determine which specific NDE technique was used most frequently. Forty State respondents, 39 county respondents, and 5 contractors answered this question. Tables 17 through 19 summarize the respondents' most commonly used NDE techniques on steel, concrete, and timber, respectively. Some respondents listed more than one technique per material. As a result, individual tallies may exceed the number of respondents. For each of the three materials, Visual Inspection was the most frequently listed technique. Visual Inspection was listed on all county responses for steel and concrete materials, and on all but one county response for timber. Visual Inspection was not as frequently listed by States, being cited on only 70 percent of the State responses. Nearly all of the county respondents listed Visual Inspection as the most frequently used technique. More than one-quarter of the State respondents indicated a most frequently used technique other than Visual Inspection for each of the three materials. These respondents may have confused Visual Inspection with visual-aided testing (boroscopes, microscopes, etc.).

Table 17. Steel NDE techniques used most by State, county, and contractor respondents.

Steel NDE Technique	State DOT	County DOT	Contractors
Visual Inspection	27	39	4
Liquid Penetrant	12	0	1
Ultrasonics	9	0	0
Magnetic Particle	3	0	2
Eddy Current	1	0	0
Mechanical Sounding	0	1	0

3.5. ***State DOT, County DOT, and Contractors:*** **Have you stopped using any NDE techniques due to unreliable performance or for any other reason? If so, which techniques and why?**

Table 18. Concrete NDE techniques used most by State, county, and contractor respondents.

Concrete NDE Technique	State DOT	County DOT	Contractors
Visual Inspection	28	39	4
Mechanical Sounding	17	6	4
Rebound Hammer	1	3	0
Cover Meter	1	0	0
Electrical Potential Measurements	1	0	0
Ultrasonics (impact-echo)	1	0	0
Coring	1	0	0

Table 19. Timber NDE techniques used most by State, county, and contractor respondents.

Timber NDE Technique	State DOT	county DOT	contractors
Visual Inspection	28	38	3
Mechanical Sounding	19	3	2
Boring/Coring	1	2	0
Moisture Meter	1	0	0

Past experiences with NDE might affect future use, so the purpose of this question was to determine whether the use of any NDE techniques had been discontinued. Thirty-four State respondents, 19 county respondents, and 4 contractors answered this question. No suspension of NDE use was reported by any of the county or contractor respondents. Similarly, 20 of the 34 State respondents indicated no suspension of use of any of the NDE techniques. The other 14 State respondents indicated that the use of some NDE techniques had been stopped. Of these respondents, three listed ultrasonics of pin/hanger connections, three listed various forms of pile testing, two listed radar, and another two listed acoustic emission. Single-response answers included magnetic particle testing, vibration analysis, cover meters, electrical potential measurements, and an impact-echo system.

3.6. ***State DOT, County DOT, and Contractors:*** **What general area of NDE applications would you like to see more research into?** ***(mark one)***

___ Concrete decks
___ Concrete superstructure
___ Steel superstructure
___ Prestressed concrete superstructure
___ Timber decks/timber substructure

The purpose of this question was to quantify the need for future research. Forty State respondents, 45 county respondents, and 4 contractors answered this question. The results are presented in figure 10. In general, research into concrete decks was one of the most frequent responses for State and county respondents. Prestressed concrete superstructures also had high response rates, especially from States and contractors. Contractors appeared to have no demand for timber substructure research or general concrete superstructure research.

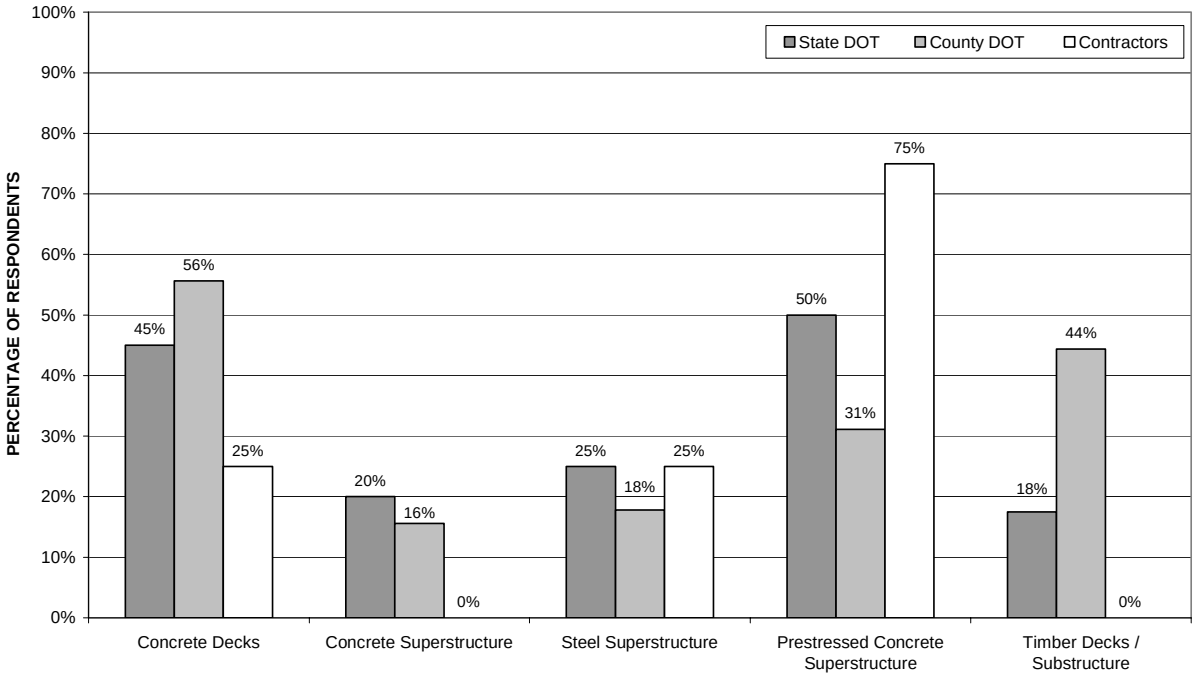


Figure 10. Need for future research.

CONCLUSIONS AND RECOMMENDATIONS

A survey was conducted to determine the state-of-the-practice for bridge inspection. Participant groups that were targeted included State DOTs, county DOTs from Iowa, and bridge inspection contractors. Responses were received from 42 State DOTs, 72 counties, and 6 inspection contractors. Components of the survey included questions focusing on inspection team composition and administrative requirements (both specifically in terms of Visual Inspection), and the general use of NDE.

The questionnaire contained three sections. Section 1 asked questions to determine information about the composition of the inspection teams. Typical questions included who performs the bridge inspections, what types of inspections contractors are used for, time and manpower budgets for a given inspection situation, PE presence during inspections and why, and experience levels for team members. Section 2 asked questions to determine information about the composition of the inspection teams. Typical questions addressed the size of the inspection units, required inspector training, procedure/policy improvements, vision testing, use of old inspection reports, the number of bridges inspected each year, and quality measures. Section 3 asked questions about the general use of NDE. Typical questions included the use of ASNT Level III inspectors, inspector certifications, NDE techniques currently used, NDE techniques used most frequently, any discontinuation of NDE techniques for any reason, and applications for future research.

CONCLUSIONS

The following conclusions are based on the research presented in this report:

- **Professional Engineers are typically not present on site for inspections.** Sixty percent of the State respondents indicated that a Professional Engineer was on site for less than 40 percent of the inspections. The two most frequent reasons States cited for a PE presence on site during inspections were that the PE was either coincidentally a member of a particular inspection team or that the PE was present as a follow-up from a previous Routine

Inspection. Of the three groups that participated, contractors indicated that they were most likely to have PEs on site during inspections.

- **The Bridge Inspector's Training Course was found to be the most frequently required training course for team leaders and team members.** Ninety-five percent of the State respondents and 92 percent of the Iowa county respondents indicated that this course was required for their team leaders. In addition, 79 percent of the State respondents and 65 percent of the Iowa county respondents indicated that this course was part of the required training for other team members.

- **Vision testing for inspectors is almost non-existent, with any employment-related vision tests (i.e., driver's license vision test) being administered to satisfy other job requirements.** Research related to the reliability of Visual Inspection in other fields, including the Nuclear Power Industry and the Aviation Industry, indicated that some industries have certification programs for their inspectors. One component of these certification procedures often includes a vision test. Only 2 of the 42 State respondents indicated that their inspectors had their vision tested. Both of these States indicated that this testing was performed to obtain driver's licenses. Similarly, only 2 of the 66 county respondents indicated that they tested the vision of their inspectors.

- **Topics for improvement suggested by the respondents for the bridge inspection process (either administrative or inspection-related) included bridge management-related issues, training and continuing education issues, and other operation areas.** The most common bridge management issue that was suggested included the incorporation of direct input of inspection data into the bridge management software program. Training topics included continuing education requirements for team leaders, and increased use and monitoring of the content of the Bridge Inspector's Training Course. Operations topics included improving bridge access, improved inspection procedures and guidelines, and additional field time for maintenance engineers, among other suggestions.

- **Visual Inspection is the most frequently used NDE technique for concrete, steel, and timber bridges. In addition, some novel NDE techniques, such as acoustic emission, radar, and thermography, are being used by State departments of transportation.** These conclusions refer to the questions regarding NDE technique use and those techniques that are used most frequently. For steel, concrete, and timber bridges, Visual Inspection was the most frequently listed response for both techniques used and the technique used most frequently.

- **NDE use has risen since 1993.** Comparisons of the usage rates of five NDE techniques from three different surveys from 1993 through 1999 have indicated a rise in the use of NDE techniques.

- **Use of ASNT Level III personnel is increasing at the State Level.** A comparison of usage rates determined from the 1994 Caltrans survey and the FHWA NDEVC survey indicates that the use of ASNT Level III personnel is on the rise. Seven States responded to the Caltrans survey that ASNT Level III personnel were used, while 14 States responded affirmatively in this survey. The increase in the number of ASNT-qualified personnel is indicative of increased NDE use within the State DOTs and is consistent with the increasing use of NDE as shown in this survey.

- **State departments of transportation and Iowa county departments of transportation feel that concrete deck research and prestressed concrete superstructure research have the most pressing need for future research.** Prestressed concrete superstructures were the top research response among States, being indicated by half of the State respondents. Concrete decks were the top research response among Iowa counties (more than half of the county respondents), as well as nearly half of the State respondents.

RECOMMENDATIONS

The following recommendations are based on the research presented in this report:

- Additional study could be performed to determine whether ensuring minimum vision standards (with corrective lenses, if necessary) through vision testing programs would benefit bridge inspection.

- Additional study could determine whether PE presence on site during inspections increases inspection reliability.

APPENDIX A. STATE DOT QUESTIONNAIRE

States Survey **Funded by the**
Nondestructive Evaluation (NDE)/Visual Inspection **Federal Highway Administration**

Please answer all questions in this voluntary survey to the best of your ability. Note that some questions may require you to respond as if you were responsible for your state's bridge inspection unit. If you wish to comment further on any question(s) or qualify your answer, feel free to include additional sheets or use the margins. Upon completion of the study, participants will receive a draft of compiled responses.

Any questions regarding this survey should be addressed to Mr. Dennis Rolander at the NDE Validation Center at (703) 285-1133. Return the completed questionnaire by **January 29, 1998** by faxing to (703) 285-1175 or mailing to:

NDE Validation Center – HNR-20
State of the Practice Survey NDE/Visual Inspection
6300 Georgetown Pike
McLean, VA 22101-2296

ATTN: Dennis Rolander

Questionnaire completed by: _____
Position/Title**:** _____
Address: _____
_____
City/State/Zip: _____
Phone No.: _____ Fax No.: _____
Email Address: _____

Section 1 – Composition of Bridge Inspection Team for Visual Inspection

1. Are your bridge inspections completed by Department of Transportation (DOT) staff or by outside Contractors? *(circle one)*

   Only DOT staff Only Contractors Both DOT staff and Contractors

2. If the answer to Question 1 is "Both DOT staff and Contractors," in what situations are Contractors utilized? *(mark all that apply)*

   _____ Routine inspections
   _____ Fracture critical inspections
   _____ Advanced NDE techniques
   _____ Complex structures
   _____ Structures with complex traffic control situations
   _____ Underwater inspections
   _____ Other *(please describe below)*

   _____
   _____

3. For the following hypothetical bridge, how many people would make-up a field inspection team (excluding traffic control personnel), and how much time (in man-hours) would be budgeted ?

   Twenty-year old, two-span bridge carrying two-lane road (medium ADT) over a small creek, maximum height above the creek is 20 ft.
   Superstructure: Steel, four-girder superstructure (rolled shapes); welded flange cover plates; concrete deck.
   Substructure: Concrete abutments, a single three-column concrete pier (with pier cap) out of the normal watercourse.

   People: _____
   Man-hours: _____

4. What are the minimum, maximum, and typical numbers of personnel that would make up a bridge inspection team (excluding traffic control personnel)?

   Minimum: _____
   Maximum: _____
   Typical: _____

5. Estimate the percentage of bridge inspections completed with a registered Professional Engineer (P.E.) **on-site**? *(circle one)*

   0-20% 21-40% 41-60% 61-80% 81-100%

6. When a P.E. is included as part of the on-site inspection team, what conditions would dictate his/her presence?

   _____
   _____

7. Please indicate the average number of years of experience in bridge inspection at each of the following positions. *(circle the appropriate responses)*

   Team Leader:
   0-5 years & PE 5-10 years More than 10 years

   Other team members:
   0-5 years 5-10 years More than 10 years

Section 2 – Impact of Administrative Requirements on Visual Inspection

1. If additional resources were made available for bridge inspection, please indicate how you might allocate those additional resources (for example, increased time per inspection, increased use of NDE methods, increased use of bridge inventory management software, etc.)?

   _____
   _____
   _____

2. Approximately how many bridge inspectors are in your bridge inspection unit?

   1-5 6-10 11-15 16-20 21-25 26-30 31-40 41-50 More than 50

3. What type of training do you require of bridge inspectors? *(mark all that apply)*

Team leaders:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Stream Stability Course
_____ Bridge Inspector's Training Course
_____ Fracture Critical Inspection Course
_____ Other Training Courses *(please specify)*

_____

_____

Other team members:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Stream Stability Course
_____ Bridge Inspector's Training Course
_____ Fracture Critical Inspection Course
_____ Other Training Courses *(please specify)*

_____

_____

4. Could you suggest any changes in administrative or inspection procedure or policy that may improve inspection performance? Explain.

_____

_____

_____

5. Do you test the vision of inspectors (with corrective lenses if necessary)? Yes No

6. For a given bridge, are copies of previous inspection reports made available to the inspectors prior to arriving at the bridge site? *(circle one)* Yes No

7. Are inspectors permitted to use copies of previous inspection reports at the bridge site? *(circle one)* Yes No

8. Who determines the order of field inspection tasks? *(Mark the most appropriate response)*

_____ "Management" provides a checklist to the on-site team to organize the inspection process.
_____ Individual inspectors on-site set the inspection process.

9. Approximately how many bridges are inspected by your organization **each year**? _____

10. What measures do you have in place to assure quality inspections?

_____

_____

_____

_____

11. Please describe any recent accomplishments of your bridge inspection program. (For example, an innovative inspector training program, successful implementation of new NDE technologies, identification of potentially life-threatening conditions, etc.).

_____

_____

_____

_____

Section 3 – Current and Future Use of NDE Techniques

1. Do you have any American Society for Nondestructive Testing (ASNT) Level III Inspectors on staff? *(circle one)*

   Yes No

   If so, what method(s) are they certified for? *(check all those that apply)*

   _____ Acoustic Emission (AE)
   _____ Electromagnetic Testing (ET)
   _____ Leak Testing (LT)
   _____ Liquid Penetrant Testing (PT)
   _____ Magnetic Particle Testing (MT)
   _____ Neutron Radiographic Testing (NRT)
   _____ Radiographic Testing (RT)
   _____ Thermal/Infrared Testing (TIR)
   _____ Ultrasonic Testing (UT)
   _____ Vibration Analysis Testing (VA)
   _____ Visual Testing (VT)

   If applicable, are these ASNT Level III Inspectors routinely used in field situations? *(circle one)*

   Yes No

2. Mark any certifications which the typical Bridge Inspection Team Member may hold? *(Mark all that apply. Note that NICET refers to the National Institute for Certification In Engineering Technologies (NICET) Bridge Safety Inspection)*

Team Leader	Other Team Members
_____ P.E. License	_____ P.E. License
_____ ASNT Level I	_____ ASNT Level I
_____ ASNT Level II	_____ ASNT Level II
_____ ASNT Level III	_____ ASNT Level III
_____ NICET Level I	_____ NICET Level I
_____ NICET Level II	_____ NICET Level II
_____ NICET Level III	_____ NICET Level III
_____ NICET Level IV	_____ NICET Level IV
_____ Other _____	_____ Other _____

3. What NDE techniques are currently utilized on bridges under your jurisdiction. *(mark all that apply)*

Steel:

Acoustic Emission	Eddy Current	Other Electromagnetic Testing
Liquid Penetrant	Magnetic Particle	Radiography
Thermal/Infrared	Ultrasonic	Vibration Analysis
Visual Inspection	Other _____	

Concrete:

Acoustic Emission	Cover Meters/Pachometers	Electrical Potential Measurements
Mechanical Sounding (chain drag)	Radar	Radiography
Rebound Hammer	Thermal/Infrared	Ultrasonics (Pulse Velocity)
Ultrasonics (Impact Echo)	Vibration Analysis	Visual Inspection
Other _____		

Timber:

Acoustic Emission	Mechanical Sounding	Moisture Meter
Radiography	Stress Wave Analysis	Visual Inspection

Other _____

Other Materials:

Material/Technique

1)
2)
3)

4. Of these NDE techniques, which method do you use most often for each material?

   Steel:_____
   Concrete: _____
   Timber:_____
   Other Materials: _____

5. Have you stopped using any NDE techniques due to unreliable performance or for any other reason? If so, which techniques and why?

   _____
   _____
   _____
   _____
   _____

6. What general area of NDE applications would you like to see more research into? *(mark one)*

   ___ Concrete decks
   ___ Concrete superstructure
   ___ Steel superstructure
   ___ Prestressed concrete superstructure
   ___ Timber decks/timber substructure

In conjunction with the development of the Federal Highway Administration's new NDE Validation Center, we plan to ask bridge inspection teams to participate in various visual inspection benchmark tests. The information gathered during these "hands-on" benchmark tests will provide bridge inspectors with valuable information about the factors affecting the reliability of visual inspection. The goal of this survey and the follow-up visual inspection tests is to help the bridge inspection community to perform more reliable bridge inspections. **Would you be willing to participate in the "hands-on" study?**

Thank you for your time in completing this questionnaire. Your answers will allow the NDE Validation Center team to focus their efforts in the areas that will benefit the bridge inspection community the most.

APPENDIX B. COUNTY DOT QUESTIONNAIRE

Iowa County Survey **Funded by the**
Nondestructive Evaluation (NDE)/Visual Inspection **Federal Highway Administration**

Please answer all questions in this voluntary survey to the best of your ability. Note that some questions may require you to respond as if you were responsible for your county's bridge inspection unit. If you wish to comment further on any question(s) or qualify your answer, feel free to include additional sheets or use the margins. Upon completion of the study, participants will receive a draft of compiled responses.

Any questions regarding this survey should be addressed to Mr. Dennis Rolander at the NDE Validation Center at (703) 285-1133. Return the completed questionnaire by **January 22, 1998** by faxing to (703) 285-1175 or using the enclosed envelope and mailing to:

NDE Validation Center – HNR-20
State of the Practice Survey NDE/Visual Inspection
6300 Georgetown Pike
McLean, VA 22101-2296

ATTN: Dennis Rolander

Questionnaire completed by: _____
Position/Title: _____
Address: _____
_____
City/State/Zip: _____
Phone No.: _____ Fax No.: _____
Email Address: _____

Section 1 – Composition of Bridge Inspection Team for Visual Inspection

1. Are your bridge inspections completed by county personnel, state personnel, or by Contractors? *(circle one)*

   County Personnel State Personnel Contractors Blend of three

2. If non-county personnel are used for bridge inspections in Question 1, in what situations are they involved? *(mark all that apply)*

   ___ Routine Inspections
   ___ Fracture Critical Member Inspections
   ___ Advanced NDE techniques
   ___ Complex structures
   ___ Structures with complex traffic control situations
   ___ Underwater inspections
   ___ Other *(please describe below)*

   _____
   _____

3. For the following hypothetical bridge, how many people would make-up a field inspection team (excluding traffic control personnel), and how much time (in man-hours) would be budgeted?

   Twenty-year old, two-span bridge carrying two-lane road (medium ADT) over a small creek, maximum height above the creek is 20 ft.
   Superstructure: Steel, fabricated four-girder superstructure ((rolled shapes); welded flange cover plates; concrete deck.
   Substructure: Concrete abutments, a single three-column concrete pier (with pier cap) out of the normal watercourse.

   People: _____
   Man-hours: _____

4. What are the minimum, maximum, and typical numbers of personnel that would make up a bridge inspection team (excluding traffic control personnel)?

   Minimum: _____
   Maximum: _____
   Typical: _____

5. Estimate the percentage of bridge inspections completed with a registered Professional Engineer (P.E.) **on-site**? *(circle one)*

   0-20% 21-40% 41-60% 61-80% 81-100%

6. When a P.E. is included as part of the on-site inspection team, what conditions would dictate his/her presence?

   _____
   _____

7. Please indicate the average number of years of experience in bridge inspection at each of the following positions *(circle the appropriate response)*.

   Team Leader:
   0-5 years (& P.E.) 5-10 years More than 10 years

   Other team members:
   0-5 years 5-10 years More than 10 years

Section 2 – Impact of Administrative Requirements on Visual Inspection

1. If additional resources were available for bridge inspection, please indicate how you might allocate those additional resources (for example, increased time per inspection, increased use of NDE methods, increased use of bridge inventory management software, etc.)?

   _____
   _____
   _____

2. Approximately how many bridge inspectors are in your bridge inspection unit?

   1-5 6-10 11-15 16-20 21-25 26-30 31-40 41-50 More than 50

3. What type and how much training do you require of bridge inspectors? *(mark all that apply)*

Team leaders:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Stream Stability Course
_____ Bridge Inspector's Training Course
_____ Fracture Critical Inspection Course
_____ Other Training Courses *(please specify)*

_____

_____

Other team members:

_____ Associate's Degree CE Technology
_____ Bachelor's Degree CE
_____ Stream Stability Course
_____ Bridge Inspector's Training Course
_____ Fracture Critical Inspection Course
_____ Other Training Courses *(please specify)*

_____

_____

4. Could you suggest any changes in administrative or inspection procedure or policy that may improve inspection performance? Explain.

_____

_____

_____

5. Do you test the vision of the inspectors (with corrective lenses if necessary)? Yes No

6. For a given bridge, are copies of previous inspection reports made available to the inspectors prior to arriving at the bridge site? *(circle one)* Yes No

7. Are inspectors permitted to use copies of previous inspection reports at the bridge site? *(circle one)* Yes No

8. Who determines the order of field inspection tasks? *(Mark the most appropriate response)*

_____ "Management" provides a checklist to the on-site team to organize the inspection process.
_____ Individual inspectors on-site set the inspection process.

9. Approximately how many bridges are inspected by your organization **each year**? _____

10. What measures do you have in place to assure quality inspections?

_____

_____

_____

_____

11. Please describe any recent accomplishments of your bridge inspection program. (For example, an innovative inspector training program, successful implementation of new NDE technologies, identification of potentially life-threatening conditions, etc.).

_____

_____

_____

_____

Section 3 – Current and Future Use of NDE Techniques

1. Do you have any American Society for Nondestructive Testing (ASNT) Level III Inspectors on staff? *(circle one)*

   Yes No

   If so, what method(s) are they certified for? *(check all those that apply)*

   _____ Acoustic Emission (AE)
   _____ Electromagnetic Testing (ET)
   _____ Leak Testing (LT)
   _____ Liquid Penetrant Testing (PT)
   _____ Magnetic Particle Testing (MT)
   _____ Neutron Radiographic Testing (NRT)
   _____ Radiographic Testing (RT)
   _____ Thermal/Infrared Testing (TIR)
   _____ Ultrasonic Testing (UT)
   _____ Vibration Analysis Testing (VA)
   _____ Visual Testing (VT)

   If applicable, are these ASNT Level III Inspectors routinely used in field situations? *(circle one)*

   Yes No

2. Mark any certifications which the typical Bridge Inspection Team Member may hold. *(Mark all that apply. Note that NICET refers to the National Institute for Certification in Engineering Technologies (NICET) Bridge Safety Inspection.)*

Team Leader	Other Team Members
_____ P.E. License	_____ P.E. License
_____ ASNT Level I	_____ ASNT Level I
_____ ASNT Level II	_____ ASNT Level II
_____ ASNT Level III	_____ ASNT Level III
_____ NICET Level I	_____ NICET Level I
_____ NICET Level II	_____ NICET Level II
_____ NICET Level III	_____ NICET Level III
_____ NICET Level IV	_____ NICET Level IV
_____ Other _____	_____ Other _____

3. What NDE techniques are currently utilized on bridges under your jurisdiction. *(mark all that apply)*

Steel:

Acoustic Emission	Eddy Current	Other Electromagnetic Testing
Liquid Penetrant	Magnetic Particle	Radiography
Thermal/Infrared	Ultrasonic	Vibration Analysis
Visual Inspection	Other _____	

Concrete:

Acoustic Emission	Cover Meters/Pachometers	Electrical Potential Measurements
Mechanical Sounding (chain drag)	Radar	Radiography
Rebound Hammer	Thermal/Infrared	Ultrasonics (Pulse Velocity)
Ultrasonics (Impact Echo)	Vibration Analysis	Visual Inspection

Other _____

Timber:

Acoustic Emission	Mechanical Sounding	Moisture Meter
Radiography	Stress Wave Analysis	Visual Inspection

Other _____

Other Materials:
Material/Technique
1)
2)
3)

4. Of these NDE techniques, which method is used most often for each material?
   Steel: _____
   Concrete: _____
   Timber: _____
   Other Materials: _____

5. Have you stopped using any NDE techniques due to unreliable performance or any other reason? If so, which techniques and why?

   _____
   _____
   _____
   _____
   _____

6. What general area of NDE applications would you like to see more research into? *(mark one)*
   ___ Concrete decks
   ___ Concrete superstructure
   ___ Steel superstructure
   ___ Prestressed concrete superstructure
   ___ Timber decks/timber superstructure

Thank you for your time in completing this questionnaire. Your answers will allow the NDE Validation Center team to focus their efforts in the areas that will benefit the bridge inspection community the most.

APPENDIX C. INSPECTION CONTRACTOR QUESTIONNAIRE

Consultant Survey
NDE/Visual Inspection

Funded by the
Federal Highway Administration

Please answer all questions to the best of your ability. Note that some questions may require you to respond as if you were responsible for all bridge inspections done by your company. If you wish to comment further on any question(s) or qualify your answer, feel free to include additional sheets or use the margins. Upon completion of the study, participants will receive a draft of the compiled responses.

Any questions regarding this survey should be addressed to Mr. Dennis Rolander at the NDE Validation Center at (703) 285-1133. Return the completed questionnaire by **January 22, 1998** by faxing to (703) 285-1175 or using the enclosed envelope and mailing to:

NDE Validation Center – HNR-20
State of the Practice Survey NDE/Visual Inspection
6300 Georgetown Pike
McLean, VA 22101-2296

ATTN: Dennis Rolander

Questionnaire completed by: _____
Position/Title: _____
Address: _____
_____
City/State/Zip: _____
Phone No.: _____ Fax No.: _____
Email Address: _____

Section 1 – Composition of Bridge Inspection Team for Visual Inspection

1. What types of bridge inspection services does your company perform? *(mark all that apply)*
   ___ Routine Inspections
   ___ Fracture Critical Member Inspections
   ___ Advanced NDE techniques
   ___ Complex structures
   ___ Structures with complex traffic control situations
   ___ Underwater inspections
   ___ Other *(please describe below)*
   _____
   _____

2. For the following hypothetical bridge, how many people would make-up a field inspection team (excluding traffic control personnel), and how much time would be budgeted?
   Twenty-year old, two-span bridge carrying two-lane road (medium ADT) over a small creek, maximum height above the creek is 20 ft.
   Superstructure: Steel, fabricated four-girder superstructure (rolled shapes); welded flange cover plates; concrete deck.
   Substructure: Concrete abutments, a single three-column concrete pier (with pier cap) out of the normal watercourse.

   People: _____
   Man-hours: _____

3. What are the minimum, maximum, and typical numbers of personnel that would make up a bridge inspection team (excluding traffic control personnel)?

   Minimum: _____
   Maximum: _____
   Typical: _____

4. Estimate the percentage of bridge inspections completed with a registered Professional Engineer (P.E.) **on-site**? *(circle one)*

   0-20% 21-40% 41-60% 61-80% 81-100%

5. When a P.E. is included as part of the on-site inspection team, what conditions would dictate his/her presence?

   _____
   _____

6. Please indicate the average number of years of experience in bridge inspection at each of the following positions. *(circle the appropriate response)*

   Team Leader:
   0-5 years & P.E. 5-10 years More than 10 years

   Other team members: *(indicate number of inspectors)*
   0-5 years 5-10 years More than 10 years

Section 2 – Impact of Administrative Requirements on Visual Inspection

1. Approximately how many bridge inspectors are in your bridge inspection unit?

   1-5 6-10 11-15 16-20 21-25 26-30 31-40 41-50 More than 50

2. Approximately how many bridges are inspected by your organization **each year**? _____

3. What type of training do you require of bridge inspectors? *(mark all that apply)*

   Team leaders:
   _____ Associate's Degree CE Technology
   _____ Bachelor's Degree CE
   _____ Stream Stability Course
   _____ Bridge Inspector's Training Course
   _____ Fracture Critical Inspection Course
   _____ Other Training Courses *(please specify)*
   _____
   _____

   Other team members:
   _____ Associate's Degree CE Technology
   _____ Bachelor's Degree CE
   _____ Stream Stability Course
   _____ Bridge Inspector's Training Course
   _____ Fracture Critical Inspection Course
   _____ Other Training Courses *(please specify)*
   _____
   _____

4. Could you suggest any changes in administrative or inspection procedure or policy that may improve inspection performance? Explain.

_____

_____

_____

5. Do you test the vision of the inspectors (with corrective lenses if necessary)? *(circle one)* Yes No

6. For a given bridge, are copies of previous inspection reports made available to the inspectors prior to arriving at the bridge site? *(circle one)* Yes No

7. Are inspectors permitted to use copies of previous inspection reports at the bridge site? *(circle one)* Yes No

8. Who determines the order of field inspection tasks? *(Mark the most appropriate response)*
   _____ "Management" provides a checklist to the on-site team to organize the inspection process.
   _____ Individual inspectors on-site set the inspection process.

9. What measures do you have in place to assure quality inspections?

_____

_____

_____

_____

Section 3 – Current and Future Use of NDE Techniques

1. Do you have any American Society for Nondestructive Testing (ASNT) Level III Inspectors on staff? *(circle one)*
   Yes No

   If so, what method(s) are they certified for? *(check all those that apply)*
   - _____ Acoustic Emission (AE)
   - _____ Electromagnetic Testing (ET)
   - _____ Leak Testing (LT)
   - _____ Liquid Penetrant Testing (PT)
   - _____ Magnetic Particle Testing (MT)
   - _____ Neutron Radiographic Testing (NRT)
   - _____ Radiographic Testing (RT)
   - _____ Thermal/Infrared Testing (TIR)
   - _____ Ultrasonic Testing (UT)
   - _____ Vibration Analysis Testing (VA)
   - _____ Visual Testing (VT)

   If applicable, are these ASNT Level III Inspectors routinely used in field situations? *(circle one)*
   Yes No

2. Mark any certifications which the typical Bridge Inspection Team Member may hold. *(Mark all that apply. Note that NICET refers to the National Institute for Certification in Engineering Technologies (NICET) Bridge Safety Inspection.)*

Team Leader	Other Team Members
_____ P.E. License	_____ P.E. License
_____ ASNT Level I	_____ ASNT Level I
_____ ASNT Level II	_____ ASNT Level II
_____ ASNT Level III	_____ ASNT Level III
_____ NICET Level I	_____ NICET Level I
_____ NICET Level II	_____ NICET Level II
_____ NICET Level III	_____ NICET Level III
_____ NICET Level IV	_____ NICET Level IV
_____ Other _____	_____ Other _____

3. What NDE techniques are currently utilized on bridges under your jurisdiction. *(mark all that apply)*

Steel:

Acoustic Emission	Eddy Current	Other Electromagnetic Testing
Liquid Penetrant	Magnetic Particle	Radiography
Thermal/Infrared	Ultrasonic	Vibration Analysis
Visual Inspection	Other _____	

Concrete:

Acoustic Emission	Cover Meters/Pachometers	Electrical Potential Measurements
Mechanical Sounding (chain drag)	Radar	Radiography
Rebound Hammer	Thermal/Infrared	Ultrasonics (Pulse Velocity)
Ultrasonics (Impact Echo)	Vibration Analysis	Visual Inspection
Other _____		

Timber:

Acoustic Emission	Mechanical Sounding	Moisture Meter
Radiography	Stress Wave Analysis	Visual Inspection
Other _____		

Other Materials:

Material/Technique

1)
2)
3)

4. Of these NDE techniques, which method is used most often for each material?

Steel: _____
Concrete: _____
Timber: _____
Other Materials: _____

5. Have you stopped using any NDE techniques due to unreliable performance or any other reason? If so, which techniques and why?

_____
_____
_____
_____
_____

6. What general area of NDE applications would you like to see more research into? *(mark one)*
   ___ Concrete decks
   ___ Concrete superstructure
   ___ Steel superstructure
   ___ Prestressed concrete superstructure
   ___ Timber decks/timber superstructure

In conjunction with the development of the Federal Highway Administration's new NDE Validation Center, we plan to ask bridge inspection teams to participate in various visual inspection benchmark tests. The information gathered during these "hands-on" benchmark tests will provide bridge inspectors with valuable information about the factors affecting the reliability of visual inspection. The goal of this survey and the follow-up visual inspection tests is to help the bridge inspection community to perform more reliable bridge inspections. **Would you be willing to participate in the "hands-on" study?**

Thank you for your time in completing this questionnaire. Your answers will allow the NDE Validation Center team to focus their efforts in the areas that will benefit the bridge inspection community the most.

APPENDIX D. COMPLETE RESULTS OF ACCOMPLISHMENTS QUESTION

STATE RESPONSES

- (1) The inspection unit now has access to a servi-lift truck. (2) Emergency repairs were made to cracks in the steel beams on an Interstate bridge in [*the State*] as a result of inspection. (3) A deteriorated superstructure was replaced on an emergency basis in [*the State*].

- [*State DOT*] has recently initiated a research project with the [*State university*] to evaluate dispersive wave techniques for determining in situ pile lengths.

- Implemented use of laptop computers and digital cameras for all teams. A sign structure was removed after inspectors found cracks.

- Inspection routine format and results computerized for consistency and error-checked by cross-comparison.

- The implementation of a spreadsheet to track priority repairs needed and rehabilitation completed on bridge elements, followed by the field verification by the inspection team, have prevented loss of life.

- Bridge program inspections are in Pontis and NBI. Laser-based clearance measuring device.

- (1) Development of observable bridge scour assessment procedure to determine scour criticality. (2) Development of new inspection forms and electronic data collection process. (3) Development and implementation of automated permit routing, analysis, permit [*illegible*] system to [*illegible*].

- [*State DOT*] has a bridge inspector certification program. Team leaders must meet all NBIS requirements in addition to passing a field proficiency test. Also, [*State DOT*] added a Level III NDT inspector in 1996.

- QC/QA Program is performing very well. Also, all inspectors are required to complete the NBI Manual 90 course. Fatigue cracking problem on [*Interstate*] over [*river*]. Two-girder system with floor beams (370+ fatigue cracks). Crack indications in truss pins on Route 11 over [*same river*]. Alternate support systems added.

- Innovative procedure for nondestructive testing of in-place pins of trusses and pin/hanger assemblies utilizing ultrasonic inspection equipment.

- Development and implementation of a Bridge Inspection Handbook (contains bridge inspection policies, procedures, directives). Development and implementation of an electronic inspection documentation and management system.

- Complete replacement of all pins statewide for pin and hanger details.

- Implementation of [*State*] roadway information management system. Purchase of laptops, digital cameras, and color printers for all inspection teams. Evaluated and are using Timber Decay Detecting Drill. Inspection team found and closed a timber bridge on the State system that was in danger of collapse.

- A 2-week training course of Bridge Inspector's Training Course in 1997. A safety class and CPR class for bridge inspection teams. A Stream Stability course in 1998.

- Use of NDE to identify a working crack in a trunion shaft of a major Interstate lift span and successful replacement of the shaft under contract.

- Development of inspector critical finding guideline. Development of inspection frequency guideline.

- Improved reporting of inspection results to local agencies. Bridge repair lists placed on Internet for maintenance crews (with photographs). Using laptop inspection

program with electronic photolog. Load testing of some bridges due to recently re-rating all State bridges. GIS for bridge database allows graphical depictions on State map of scour-critical bridges, needed inspections, and inspection scheduling.

- Concrete pile PIT testing. Coastal scour hydrology/hydraulic studies. Use of scour monitoring equipment.

- The State Inspectors using dye-penetrant kits discovered a severe fatigue cracking problem that led to a university research project to identify the cause and recommend procedures for repair. The State NBIS underwater inspectors this past year inspected all State bridges affected by two natural flood disasters that led to emergency actions to avoid failures due to scour and erosion. The State implemented a load test program to proof load rate bridges posted for 1 to 5 tons under legal limit to allow for removing the posting restriction where practical.

- Use of portable fathometers. Electronic element-level data collection.

- A number of bridges are closed each year based on findings. Underwater inspections have found threatening conditions twice.

- [*State DOT*] has implemented the Pontis BMS system with element inspections. [*State DOT*] is testing digital cameras and we are using automated inspection software.

- Implementation of automation software.

- [*State DOT*] has developed and implemented an Access-based computer program which is used by their inspectors, engineers, and managers to record inspection findings, to schedule inspections, and to schedule and track planned maintenance and repairs.

- Rope-climbing equipment and related training was provided during the last year.

- One inspector is Level III and two inspectors are Level II qualified (ASNT).

- [*Written*] QA/QC procedure.

- [*State DOT*] is supplementing their traditional hydrographic methods by contracting for side-scan sonar services on those bridges which most concern them.

- Select structures on the Fracture-Critical Master List have been analyzed to determine if they are, in fact, fracture critical and also identify fracture-critical elements which should receive more in-depth inspections.

- [*State DOT*] recently got back on a 2-year schedule.

- All bridge inspectors are certified in Red Cross First Aid and CPR. All bridge inspectors are scuba certified for underwater inspections.

- NDE technologies are being used on pin/hanger connections. Consultant has been hired to perform the evaluations.

- [*State DOT*] uses rope-climbing techniques and equipment to inspect some bridges.

COUNTY RESPONSES

- Identifying areas of advanced decay or scour and closing the bridges to traffic until repaired.

- Changing over to Pontis bridge inspection techniques.

- Identified corrosion and subsequent settlement of a steel-beam bridge. Closed, repaired, and reopened bridge and finally constructed a new structure. Identified settlement in timber piles and corrected [*the problem*].

- Completed bridge scour rating on all bridges.

- Timely identification of bridges needing posting and/or closure.

- In 1995, [*County DOT*] noticed abutment problems on a wood trestle bridge. In 1996, when new bridge was under construction at new location, the abutment of the old bridge failed.

- Started using a new and more thorough field inspection form in the last 2 years.

- Develop repair list. Broken down by in-house or contractor and priority.

- Reporting of damaged bridge components. Inspection interval of every 2 years or more frequently if bridge warrants such.

- Identifying areas of advanced decay or scour and closing the bridges to traffic.

- Developing a computerized bridge inspection inventory program.

- Removed 6 ft^2 of asphalt concrete overlay and partially removed concrete deck to expose rusted rebar on 28-ft by 610-ft bridge. Scheduled deck for replacement. [*County DOT*] has re-analyzed all timber and I-beam bridges, resulting in posting of 40 bridges.

- Compliment from FHWA bridge inspector regarding problem bridges being scheduled into the DOT budget and program.

- [*County DOT*] has found major problems with three bridges carrying their gravel roads over railroad tracks. [*County DOT*] has removed two and replaced them with at-grade crossings. [*County DOT*] regraded the roads and paid all expenses for the change.

- Scour-Critical.

- Enrollment of inspector in NHI Bridge Inspection courses in spring of 1999.

- Bridges are inspected on an almost daily basis by [*County*] truck drivers, motor patrol operators, and farmers. Reporting observed deficiencies of railings, signs, loss of backfill, etc.

- Annually, potential problems are discovered and addressed. [*County DOT*] has many bridges from 1800's.

- Bridges have been closed or severely limited to weight after inspections have discovered critical problems.

REFERENCES

1. *Code of Federal Regulations, "National Bridge Inspection Standards" – 23CFR650*. U.S. Government Printing Office via GPO Access, revised April 1, 1998, pp. 238-240.

2. Caltrans unpublished data

3. *The American Society for Nondestructive Testing, Recommended Practice No. ASNT-TC-1A, 1996*. The American Society for Nondestructive Testing, Columbus, OH, 1996.

4. Rens, Kevin L.; Terry J. Wipf; and F. Wayne Klaiber. "Review of Nondestructive Evaluation Techniques of Civil Infrastructure," *Journal of Performance of Constructed Facilities,* Vol. 11, No. 4, November 1997, pp. 152-160.

5. Rens, Kevin L. and David J. Transue. "Recent Trends in Nondestructive Inspections in State Highway Agencies," *Journal of Performance of Constructed Facilities,* Vol. 12, No. 2, May 1998, pp. 94-96.

6. Phares, Brent M. "A Design Methodology for a Low-Volume Road Bridge Alternative: Steel Beam Precast Units," Dissertation, Iowa State University, 1998.