

FHWA INTERNATIONAL TECHNOLOGY EXCHANGE PROGRAMS

BRIDGE EVALUATION QUALITY ASSURANCE

SUMMARY REPORT—July 2007

Overview

One of the primary goals of the U.S. transportation community is to improve safety on our nation's roadways. In response to that goal, Federal, State and local transportation agencies consider the inspection of our nearly 600,000 bridges to be vitally important. These agencies invest significant funds into bridge inspection activities each year. There is high interest in making sure that the quality of our bridge inspection program is maintained at the highest level, and that our funds are utilized as effectively as possible.

Towards that end the National Bridge Inspection Standards (NBIS) were established to set minimum standards for a nationwide bridge inspection program. This program has become very successful at preventing failures and assuring the public that the bridges they cross remain safe. However, at the State and local levels, quality control/quality assurance programs (QC/QA) associated with bridge inspection are quite disparate, and there has been little focus on QC/QA programs from the federal level in the past. The January 2005 revision to the NBIS specifically requires State and federal agencies to assure that QC/QA procedures are used to maintain a high degree of accuracy and consistency in the bridge inspection program. In addition, many bridge owners have elected to collect data beyond that required by the NBIS. Better knowledge of QC/QA programs and data types collected abroad should provide meaningful advice to our transportation community.

The Federal Highway Administration (FHWA) and most bridge owners also have strategic goals related to improving the overall condition of our bridges and tactical programs aimed at extending service life. These goals are commonly derived from the interpretation of bridge deficiency data identified and documented through the bridge inspection program. Additionally, FHWA utilizes the inspection data as one of the factors for allocation and distribution of Highway Bridge Program funds. Improving the overall quality and determining the right data is reported through our inspection program will aid in maintaining a high level of safety for the traveling public, ensuring effective use of limited funds, equitable distribution of funds and helping bridge owners achieve their safety and mobility goals.

The results of this Scan are intended to assist bridge owners and the FHWA in implementing provisions of the 2005 NBIS regulation. Although many QC/QA programs exist within the U.S., there was significant interest in exploring the most effective bridge inspection systems in other countries. FHWA is also obligated to satisfy the guidelines provided through the Data Quality Act passed by the U.S. Congress in 2001. The data that is collected through the U.S. bridge inspection program not only ensure that our bridges are safe for the traveling public but, also

help form the basis for programming bridge maintenance, repair, rehabilitation, and replacement activities.

The Scan Team was co-sponsored by the American Association of State Highway and Transportation Officials (AASHTO), the FHWA, an agency of the U.S. Department of Transportation and, the National Cooperative Highway Research Program (NCHRP). The Scan was organized by American Trade Initiatives, Inc

Scan Team Topics of Interest included:

1. Organizational Structure and Background
2. Inspection Data
3. Personnel Qualifications
4. Process Control
5. Equipment
6. Documentation

The team conducted a series of meetings and site visits with representatives of government agencies and private sector organizations abroad during the period of 1 – 17 June 2007. The ten-member team included three representatives from FHWA, four representatives from State DOTs, one representative from county engineers, one university representative, and one representative from industry. The panel visited Finland, Denmark, Germany, and France and met with representatives from Sweden and Norway while in Denmark. The countries were selected because of their advanced activities in Bridge Evaluation, Bridge Management and Quality Assurance in their practices.

Summary of Initial Findings

Generally speaking, the team found that the European host agencies put a tremendous value in their bridge inspection programs not only to insure highway user safety but also to insure that durability and serviceability expectations were met and to enhance capital investment decisions regarding their existing bridge inventory. As such major emphasis was placed on providing for quality assurance through well-defined inspector qualifications, periodic calibration of inspectors, data collection processes, and the use of appropriate equipment to evaluate their structures. Most all of the agencies visited had major programs aimed at inspection uniformity, developed a multi-tiered inspection program and had procedures for performing damage assessment and programming maintenance and repair thru their inspection process.

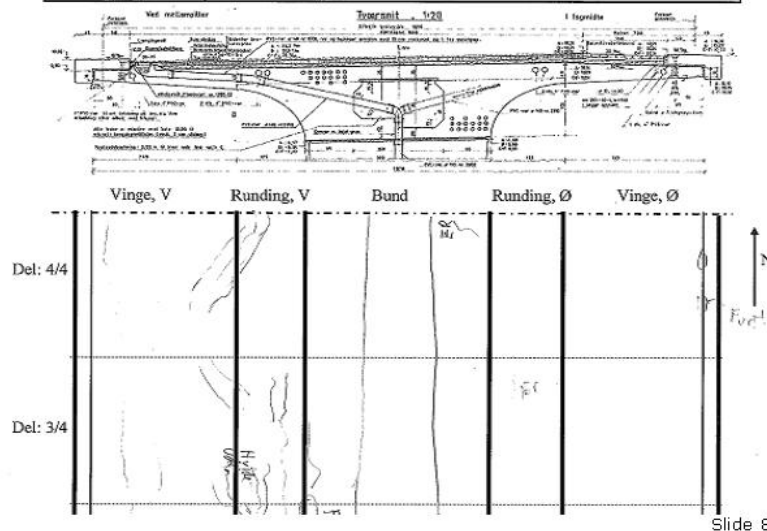
The Scan Team identified 101 bridge inspection practices and technologies related to the previously stated topics of interest. Of these 101 items, the team determined 41 items organized into ten topic areas that supported the scan team's topics of interest that might significantly enhance bridge inspection practices within the U.S. Those topic areas are as follows.

1. Detailed and Illustrated Inspection References and Tools

Many very detailed, heavily illustrated manuals and references were available as tools for bridge inspectors. To focus inspectors and to provide more uniform ratings, types of damage with performance indices were quantified. Several countries had implemented standards to quantify concrete cracking in inspection reports. European inspectors were observed to have photographs from past inspections with them on site for their use in current inspections. Inspection vehicles in Germany were fully equipped with field equipment, office space and bridge records to support activities at the inspection site.

Standard data sheets for registration of damage

Nørresundbygrenen, 2005		Side: 4 af 5
Projekt: 543034	Dato: 1/6 - 2005	Init.: MATY
Emne:	US* - Visual	
Faglængder:	Fag: F1/F5=24,5 m; F2/F4=32,5 m; F3=35,5 m	
Fagnummer: F1		



RAMBOLL

Slide 8

2. Reports and Data Management

Standardization of Inspection reports, forms, terms and ratings was practiced by all countries visited. Noteworthy practices included the generation of customized bridge inspection forms by

Bridge Management Systems, standardization of terms and rating criteria for inspectors, embedment of digital photographs in inspection reports and requiring designers to identify critical areas of a structure to be inspected. In the field, the inspectors include a level of urgency for any required repair in their assessment of damage found. This level of urgency is used to determine annual allocations of funds, programming maintenance repairs, and tracking repair backlogs.

In Germany, a computer program in which inspectors select a structural condition from a pull down menu allowing a program to generate a rating is in use. In Denmark separate Asset Management policies, systems, and practices have been established for major structures to allow better decision making for capital investments. The Finnish index their Bridge Management Data in a GIS system.



IQOA grades

BRIDGES IN APPARENTLY GOOD CONDITION	<i>need nevertheless common maintenance</i> CLASS 1
BRIDGES WITH DEFECTS ON EQUIPMENTS OR PROTECTION ELEMENTS OR MINOR STRUCTURAL DAMAGES	<i>need specialized maintenance without urgency to repair</i> CLASS 2
	<i>need specialized maintenance with urgency to repair in order to prevent increase of defects in the structure</i> CLASS 2E
DAMAGED STRUCTURE	<i>needs repair without urgency to repair</i> CLASS 3
	<i>needs repair with urgency to repair</i> CLASS 3U



3. Bridge Inspector training and certification

A variety of approaches are taken by countries in Europe to train and certify inspectors. All had technical educational requirements for inspectors; most requiring inspectors have a degree in engineering. Many had specialized training requirements for inspectors to insure the quality of the inspection and the data it provided. In France, training is targeted at the Inspector, Team

leader and Program manager through six modules of training. Individuals must pass an exam to fill a position in each level. Several countries match the experience of the inspector with the complexity of bridge being inspected. Maintaining a core of in-house staff, expert in bridge inspection, is a high priority for European owners. .

4. Defined Inspection Types

All of the countries visited had very clear definitions of inspection types, however a major finding was that the frequency of detailed inspections was typically five to six years with minor inspections focused on areas of interest identified in the detailed inspection conducted in the interim. There was a much greater dependence on road maintenance supervisors to routinely monitor and report issues of structural condition. European road agencies typically require inspection of structures starting at spans of two meters.

5. Frequency of inspection determination

A typical finding was that European agencies had developed a technical decision making process for determining inspection frequency. Usually included in this process was the competency of the inspection crew. Inspector qualifications and experience requirements by agencies provided confidence in allowing inspectors to determine the duration between cycles of inspections typically up to five or six years but up to nine years in France. The use of risk acceptance criteria for structural condition of elements determined during inspection to drive agency rehabilitation and maintenance actions was being practiced in Denmark and France.

6. Use of Reference Bridges

The Finnish Road Administration (Finnra) uses a sampling of 106 bridges and 26 steel culverts as a control sample or set of Reference Bridges. Baseline data is gathered from these bridges by experienced in-house bridge inspection staff to provide consistency. Data gathered is used to fulfill a variety of needs. These needs include:

- A. Gather data on bridge serviceability and durability over time.
- B. Trend analysis of data gathered on similar bridges and updating of deterioration models in their bridge management system
- C. Quality Control of inspection data from non Reference Bridges by providing baseline data for comparison
- D. Training and Refresher Training of Inspectors and evaluation of inspector condition ratings against condition ratings provided by in-house staff. This evaluation is also used to provide “quality points” for selection of consultant inspectors.

Several agencies also use bridges to be demolished to evaluate the effectiveness of NDT methods when possible.

NDT Tool box

1-page information sheets/method

- field of application

- description

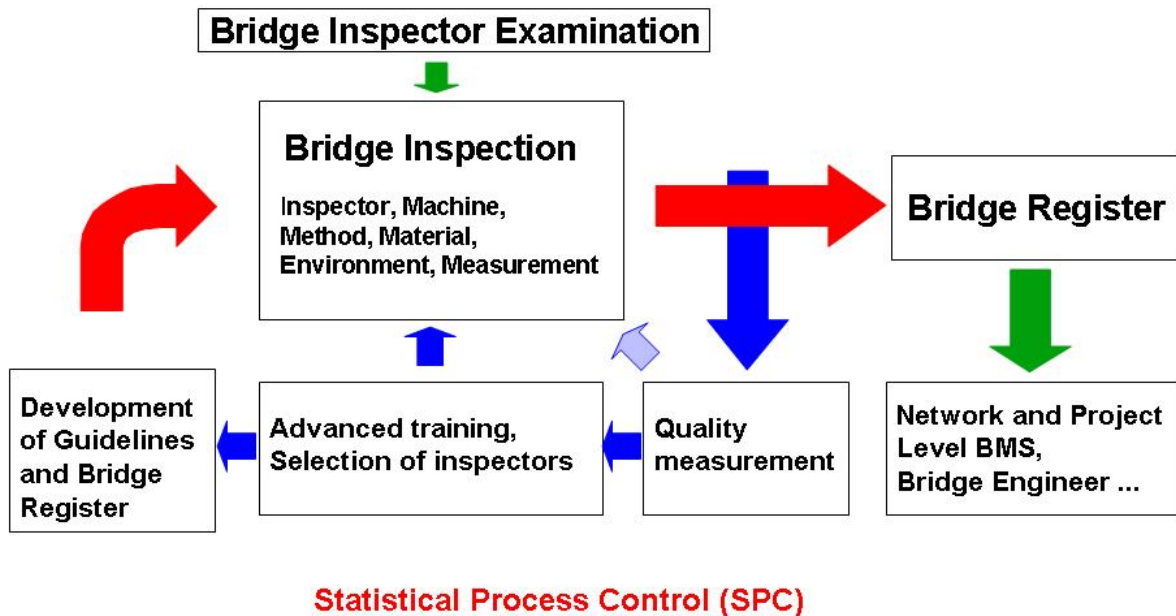
- limitation etc

SUSTAINABLE BRIDGES

Ultrasonic (US) echo RC, PTC		Sustainable Bridges		Radiography Steel		Sustainable Bridges		Low Strain Pile Integrity Testing		Sustainable Bridges			
Field of application	Inspection of the inner structure of structural elements made of reinforced or cast-in-place concrete (slab + reinforcement, connection built-up joints)	Field of application	Inspection of the inner structure of structural elements made of all types of steel. Verification of indications (defects, segregations cavities in sandwiched elements or of the weld quality)	Field of application	Inspection of the inner structure of structural elements made of all types of steel. Verification of indications (defects, segregations cavities in sandwiched elements or of the weld quality)	Field of application	Inspection of the inner structure of structural elements made of all types of steel. Verification of indications (defects, segregations cavities in sandwiched elements or of the weld quality)	Field of application	Determination of foundation pile length and integrity, localisation of cracks, diameter changes, quality, deterioration, embedment of piles (concrete, steel, wood)	Field of application	Determination of foundation pile length and integrity, localisation of cracks, diameter changes, quality, deterioration, embedment of piles (concrete, steel, wood)		
Description	Pulses are transmitted into concrete and their reflections are analysed with respect to reflections at interfaces and internal reflectors. Several point measurements are combined to visualise the reflection along a line or parallel to the surface images. Dry coupling of arrays is possible (point contact transducer)	Description	Gamma radiation radiates a steel plate, welds or built-up sections (e.g. of riveted steel elements). Films or image plates are fixed to the opposite plate surface, after exposure to the penetrator radiation, the film is developed.	Description	Gamma radiation radiates a steel plate, welds or built-up sections (e.g. of riveted steel elements). Films or image plates are fixed to the opposite plate surface, after exposure to the penetrator radiation, the film is developed.	Description	Gamma radiation radiates a steel plate, welds or built-up sections (e.g. of riveted steel elements). Films or image plates are fixed to the opposite plate surface, after exposure to the penetrator radiation, the film is developed.	Description	Pile head or shaft near head is struck vertically with a hammer. A sensor records the movement of the pile head. Length of pile or depth of defects is determined by measuring the travel time of echoes or analysis in the frequency domain (impulse response).	Description	Pile head or shaft near head is struck vertically with a hammer. A sensor records the movement of the pile head. Length of pile or depth of defects is determined by measuring the travel time of echoes or analysis in the frequency domain (impulse response).	Description	Pile head or shaft near head is struck vertically with a hammer. A sensor records the movement of the pile head. Length of pile or depth of defects is determined by measuring the travel time of echoes or analysis in the frequency domain (impulse response).
Physical principle	Broadband pulses are generated in the frequency range of 50 to 150 kHz. With a known wave propagation velocity (calibrated at a point with known thickness), the depth of the reflector can be evaluated from the measured pulse travel time. In most cases the measured data is evaluated with reconstruction calculation (D-GAST). The relative intensity of the reflected wave give information about the boundary condition of different layers and presence of air inclusions.	Physical principle	Gamma radiation (portions of very short radioactive waves) e.g. Iridium, radiates the steel element. After penetration, gamma radiation visualises defects as grey value image on the film or image plate	Physical principle	Gamma radiation (portions of very short radioactive waves) e.g. Iridium, radiates the steel element. After penetration, gamma radiation visualises defects as grey value image on the film or image plate	Physical principle	Gamma radiation (portions of very short radioactive waves) e.g. Iridium, radiates the steel element. After penetration, gamma radiation visualises defects as grey value image on the film or image plate	Physical principle	An elastic wave is generated by the hammer. It travels down the pile and is reflected at major defects and the pile toe.	Physical principle	An elastic wave is generated by the hammer. It travels down the pile and is reflected at major defects and the pile toe.	Physical principle	An elastic wave is generated by the hammer. It travels down the pile and is reflected at major defects and the pile toe.
Limitation	The propagation of ultrasonic waves is limited by layers containing air, e.g. concrete with large amount of air pores and by very dense reinforcing rebars.	Limitation	Standard < 90 mm test class B (EN 446)	Limitation	Standard < 90 mm test class B (EN 446)	Limitation	Standard < 90 mm test class B (EN 446)	Limitation	Wave velocity not exactly known in most cases - calibration needed Only major defects detectable Pile toe may be not visible if major defects present	Limitation	Wave velocity not exactly known in most cases - calibration needed Only major defects detectable Pile toe may be not visible if major defects present	Limitation	Wave velocity not exactly known in most cases - calibration needed Only major defects detectable Pile toe may be not visible if major defects present
Characterisation		Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other	Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other	Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other	Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other	Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other	Characterisation	Visual <input type="checkbox"/> Electrical/Electromagnetic <input type="checkbox"/> Acoustic <input type="checkbox"/> Chemical <input type="checkbox"/> Other
Physical principle		Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive	Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive	Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive	Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive	Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive	Physical principle	Non-Destructive <input type="checkbox"/> Minor destructive <input type="checkbox"/> Destructive
NTD/ destructive		NTD/ destructive	Single test <input type="checkbox"/> Monitoring	NTD/ destructive	Single test <input type="checkbox"/> Monitoring	NTD/ destructive	Single test <input type="checkbox"/> Monitoring	NTD/ destructive	Single test <input type="checkbox"/> Monitoring	NTD/ destructive	Single test <input type="checkbox"/> Monitoring	NTD/ destructive	Single test <input type="checkbox"/> Monitoring
Type of test		Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low	Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low	Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low	Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low (for interpretation)	Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low (for interpretation)	Type of test	High <input type="checkbox"/> Medium <input type="checkbox"/> Low (for interpretation)
Equipment Cost		Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory	Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory	Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory	Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory	Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory	Equipment Cost	Inspector alone <input type="checkbox"/> Inspector + specialist <input type="checkbox"/> Specialised laboratory
Required education		Required education		Required education		Required education		Required education		Required education		Required education	
Examination level		Examination level		Examination level		Examination level		Examination level		Examination level		Examination level	
Accuracy	The finding of insufficient grouting in order research with good results in laboratory applying reconstruction calculation. The accuracy is depending on the choice of emitted wave length (depends on size of aggregates) 1% - 2cm	Accuracy	Accuracy for the min. dimension of voids depends on the focus of the source (Point and geometry. Min. indication size: 0.5 mm (depends on the parameters above))	Accuracy	Accuracy for the min. dimension of voids depends on the focus of the source (Point and geometry. Min. indication size: 0.5 mm (depends on the parameters above))	Accuracy	Accuracy for the min. dimension of voids depends on the focus of the source (Point and geometry. Min. indication size: 0.5 mm (depends on the parameters above))	Accuracy	Length determination: depth of defects 5-10% (without calibration), 1-5% (with calibration). Detection of defects: only 1-20% of cross section	Accuracy	Length determination: depth of defects 5-10% (without calibration), 1-5% (with calibration). Detection of defects: only 1-20% of cross section	Accuracy	Length determination: depth of defects 5-10% (without calibration), 1-5% (with calibration). Detection of defects: only 1-20% of cross section
Required equipment	Transducer arrays with point contact transducers, which don't require coupling agent (producer: ACSYS, Moscow). Large data sets have to be stored for later evaluation. Automated measurement applying scanners is recommended.	Required equipment	Radon source: Ir-192, Radiation dose rate measurement device, radiographic film (film), Developer or image plate system (CR), Computer radiography	Required equipment	Radon source: Ir-192, Radiation dose rate measurement device, radiographic film (film), Developer or image plate system (CR), Computer radiography	Required equipment	Radon source: Ir-192, Radiation dose rate measurement device, radiographic film (film), Developer or image plate system (CR), Computer radiography	Required equipment	Hammer (with force sensor, if available), sensor piezoelectric accelerometer, recording unit, processing software, Commercial equipment available.	Required equipment	Hammer (with force sensor, if available), sensor piezoelectric accelerometer, recording unit, processing software, Commercial equipment available.	Required equipment	Hammer (with force sensor, if available), sensor piezoelectric accelerometer, recording unit, processing software, Commercial equipment available.
Advantages	Accessibility only from one side, no safety restrictions (as for X-ray)	Advantages	Systems for use on site is fast applicable. Results for measurement can be obtained immediately with new equipment to a CR, that delivers digital images.	Advantages	Systems for use on site is fast applicable. Results for measurement can be obtained immediately with new equipment to a CR, that delivers digital images.	Advantages	Systems for use on site is fast applicable. Results for measurement can be obtained immediately with new equipment to a CR, that delivers digital images.	Advantages	Fast easy to apply, no boreholes or large excavation works necessary.	Advantages	Fast easy to apply, no boreholes or large excavation works necessary.	Advantages	Fast easy to apply, no boreholes or large excavation works necessary.
Disadvantages	Limited imaging of planar elements transducers to rough concrete surfaces, even for point contact transducers the unevenness has to be < 5 mm.	Disadvantages	Not applicable for elements accessible only from one side	Disadvantages	Not applicable for elements accessible only from one side	Disadvantages	Not applicable for elements accessible only from one side	Disadvantages	Access to pile head or shaft near head needed. Interpretation needs experience operator.	Disadvantages	Access to pile head or shaft near head needed. Interpretation needs experience operator.	Disadvantages	Access to pile head or shaft near head needed. Interpretation needs experience operator.
Time consumption	For 1 m ² with 5 cm grid: 44 min per 1 m ² (automated scanning: 6 s per point). Data preprocessing and reconstruction of data: ~10 min	Time consumption	Up to 30 min (depending on the penetrated wall thickness and the remaining activity of the Gamma source. CR reduces the exposure time up to 30%)	Time consumption	Up to 30 min (depending on the penetrated wall thickness and the remaining activity of the Gamma source. CR reduces the exposure time up to 30%)	Time consumption	Up to 30 min (depending on the penetrated wall thickness and the remaining activity of the Gamma source. CR reduces the exposure time up to 30%)	Time consumption	Time needed for measurement: Up to 30 min/day (with preparing access) Time for evaluation of data in the office: 30 min/day (without report)	Time consumption	Time needed for measurement: Up to 30 min/day (with preparing access) Time for evaluation of data in the office: 30 min/day (without report)	Time consumption	Time needed for measurement: Up to 30 min/day (with preparing access) Time for evaluation of data in the office: 30 min/day (without report)
Comments	Automated scanning system recommended, hand held measurement for small areas as possible. Application to bridges is in research stadium, proposed for use in close with local and foreign, one of the most appropriate techniques.	Comments	Well developed method and equipment. Standard method in industry, a credible information, volume testing, sizing (length and position of damage). Laser radiographic method (LRI) allows the determination of the depth of indication.	Comments	Well developed method and equipment. Standard method in industry, a credible information, volume testing, sizing (length and position of damage). Laser radiographic method (LRI) allows the determination of the depth of indication.	Comments	Well developed method and equipment. Standard method in industry, a credible information, volume testing, sizing (length and position of damage). Laser radiographic method (LRI) allows the determination of the depth of indication.	Comments	The only method available for the investigation of a large number of existing piles. For new piles Crosshole Sonic Logging may be an alternative.	Comments	The only method available for the investigation of a large number of existing piles. For new piles Crosshole Sonic Logging may be an alternative.	Comments	The only method available for the investigation of a large number of existing piles. For new piles Crosshole Sonic Logging may be an alternative.
Standards, guidelines	None, only recommendations: e.g. EA 92/04, DGGP (AEL) - recommendation BR	Standards, guidelines	EN 446, EN 447, EN 448, EN 449, EN 450, EN 451, EN 452, EN 453, EN 454, EN 455, EN 456, EN 457, EN 458, EN 459, EN 460, EN 461, EN 462, EN 463, EN 464, EN 465, EN 466, EN 467, EN 468, EN 469, EN 470, EN 471, EN 472, EN 473, EN 474, EN 475, EN 476, EN 477, EN 478, EN 479, EN 480, EN 481, EN 482, EN 483, EN 484, EN 485, EN 486, EN 487, EN 488, EN 489, EN 490, EN 491, EN 492, EN 493, EN 494, EN 495, EN 496, EN 497, EN 498, EN 499, EN 500, EN 501, EN 502, EN 503, EN 504, EN 505, EN 506, EN 507, EN 508, EN 509, EN 510, EN 511, EN 512, EN 513, EN 514, EN 515, EN 516, EN 517, EN 518, EN 519, EN 520, EN 521, EN 522, EN 523, EN 524, EN 525, EN 526, EN 527, EN 528, EN 529, EN 530, EN 531, EN 532, EN 533, EN 534, EN 535, EN 536, EN 537, EN 538, EN 539, EN 540, EN 541, EN 542, EN 543, EN 544, EN 545, EN 546, EN 547, EN 548, EN 549, EN 550, EN 551, EN 552, EN 553, EN 554, EN 555, EN 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681, EN 682, EN 683, EN 684, EN 685, EN 686, EN 687, EN 688, EN 689, EN 690, EN 691, EN 692, EN 693, EN 694, EN 695, EN 696, EN 697, EN 698, EN 699, EN 700, EN 701, EN 702, EN 703, EN 704, EN 705, EN 706, EN 707, EN 708, EN 709, EN 710, EN 711, EN 712, EN 713, EN 714, EN 715, EN 716, EN 717, EN 718, EN 719, EN 720, EN 721, EN 722, EN 723, EN 724, EN 725, EN 726, EN 727, EN 728, EN 729, EN 730, EN 731, EN 732, EN 733, EN 734, EN 735, EN 736, EN 737, EN 738, EN 739, EN 740, EN 741, EN 742, EN 743, EN 744, EN 745, EN 746, EN 747, EN 748, EN 749, EN 750, EN 751, EN 752, EN 753, EN 754, EN 755, EN 756, EN 757, EN 758, EN 759, EN 760, EN 761, EN 762, EN 763, EN 764, EN 765, EN 766, EN 767, EN 768, EN 769, EN 770, EN 771, EN 772, EN 773, EN 774, EN 775, EN 776, EN 777, EN 778, EN 779, EN 780, EN 781, EN 782, EN 783, EN 784, EN 785, EN 786, EN 787, EN 788, EN 789, EN 790, EN 791, EN 792, EN 793, EN 794, EN 795, EN 796, EN 797, EN 798, EN 799, EN 800, EN 801, EN 802, EN 803, EN 804, EN 805, EN 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differences from control ratings are noted. Finland also has a defined QC/QA plan that is made a part of their agreement for consultant bridge inspection services.

The Control System of the Bridge Inspection process in FinnRA



Another item of interest in European agencies is the practice of review of a sampling of reports by senior office staff. Several agencies have processes for the office review and field check of reports submitted by senior in house inspectors.

9. Cause of Failure Determination

Most of the agencies visited include a cause of failure investigation by the inspector as part of their bridge inspection procedure. Inspectors are trained to assess damage to a structural element based on structural stability, user safety and effect on the damaged component's durability and recommend action. Using the inspector's knowledge of structures, coupled with a determination of urgency, an agency can calculate the immediate and short term programming levels required. All agencies had procedures that would initiate actions based on the severity of the condition found with or without a higher level of review and approval. Maintenance activities were generally tracked by all agencies in their bridge records.

In general, there is a greater emphasis on characterizing a particular defect in the bridge. This is in contrast to the U.S. approach of characterizing the element or component, which essentially characterizes the effect of the defect rather than the defect itself. As a result of this focus on

defect characterization, there is a greater integration of mitigation strategies, i.e. specific repair and rehabilitation activities specified by the inspector.

10. Other

Two additional items of interest were identified for consideration in the U.S. by the team. First was a DVD developed for use in Germany, “Inspection According to German Industrial Standard (DIN) No 1076”. The DVD is intended for viewing by the general public and outlines the reasons for bridge and structure inspection. The DVD not only provides an informative overview of the inspection process, it appears to be a useful mechanism for maintaining support for bridge inspection activities from its audience.

Second, the general practice of European agencies was not to use dedicated inspectors on the same bridge but to rotate Inspectors on subsequent inspections. This practice provides a fresh assessment of the bridge’s condition, which in turn should provide for a more reliable or at least confirmation of its true condition.



(2) Acoustic Methods Ultrasonic Echo/ Impact-Echo

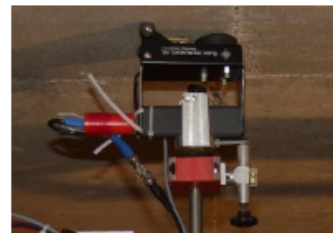
- Reflections at interfaces of materials with different acoustical properties

Ultrasonic Measurement Device



- **Shear waves**
 - center frequency of 50 kHz
- **Measurement head**
 - 24 point-contact transducers
 - without coupling agent

Impact-Echo Measurement Device



- **Frequency range**
 - from 1Hz to 40 kHz
- **Frequency spectrum analysis**
 - multiple reflections (recorded in the time domain)

Recommendations

Based on the above findings, the preliminary general recommendations of the team are as follows:

1. Develop a basis for determining bridge inspection frequencies combining different levels of inspection intensity with clear standards for inspector education, training and qualification based on factors such as safety, condition, age of the structure and engineering judgment.
2. Draft Guidelines for Developing QC/QA procedures for consideration by States for use by in-house staff as well as similar guidelines to be made a part of bridge inspection services contracts.
3. Development of Integrated Inspection-Repair Approaches to be used by bridge inspectors
4. Development of a detailed coding guide complete with Illustrations and reference photos
5. Development of a web-based library (wiki library) of references and technologies identified by the scan team that are potentially ready to implement within the U.S.. Potential references and technologies include:
 - i. Crack Mapping used keys and 2-D scaled representations
 - ii. Method for quantifying map cracking
 - iii. NDE toolbox data sheets from the sustainable bridges project
 - iv. Expanded inventory of access equipment for bridge inspection
 - v. Available data from the EU Sustainable Bridge Project
 - vi. NDT compendium
 - vii. Silko Manual from Finra
6. Initiate a Demonstration Project around the Ultrasonic Shear Wave Transducer for use in identifying defects in concrete.
7. Develop additional Technical Interchange with the Finnish Roads Administration on their work applying Statistical Methods to Bridge Inspection Quality Assurance including reference bridges.
8. Develop additional Technical Interchange with other EU countries on sharing of information on the long-term performance of bridges as the new Long Term Bridge Performance program being initiated by FHWA's Turner Fairbanks Laboratory progresses.

Planned implementation actions

The scanning team has already scheduled many presentations at national technical meetings sponsored by FHWA, AASHTO, and other organizations to disseminate information from the scanning tour beginning the second week of July 2007. In addition, the team has formed a group that prepared a draft Scanning Technology Implementation Plan that also served as the basis for the recommendations described above. An initial draft of these implementation items was prepared and approved for final development by the entire team at its final meeting in Germany.