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5.1 GENERAL OVERVIEW AND SUMMARY TABLE

5.1.1 Introduction

Structures of all types are susceptible to a range of defects (flaws and discontinuities). Some defects are unknowingly built into a structure, while others develop with time due to natural or manmade events. While some of these defects may be detected by visual or tactile means, others may be hidden within the structure's members or components. In some cases, an indication of a defect may be readily observed, but the true extent or cause of the defect is not evident. For these cases, the use of nondestructive evaluation (NDE) methods or partially destructive evaluation (PDE) methods can be used to more thoroughly investigate a structure's condition. NDEs permit the inspection of an element without inflicting damage, while PDEs typically cause minor localized, repairable damage. Specifically, NDE and PDE are used to investigate the material integrity of the test component and not the function of the component beyond material failure.

Part 5 presents an overview of NDE techniques as they apply to bridges and miscellaneous support systems. Although NDE is often performed by specialists, all structure inspectors should be familiar with available NDE techniques so they can recommend appropriate testing procedures and recognize the limitations of the data.

A variety of NDE and PDE techniques have been developed and commonly employed in the inspection of structures. While several of these techniques are described in Part 5, the inspector should be aware that many other methods are also currently available and new techniques are constantly being developed. Refer to Figure 5.1.1-1 for a brief comparison of the techniques covered in Part 5.

Chapter	Method	Nondestructive	Partially Destructive	Material			Desired Information, Measured Defect or Material Property
				Concrete	Steel	Timber	
2	Visual Inspection	X		X	X	X	Overall external material deterioration.
3	Audible Inspection	X		X	X	X	Concrete delamination; steel bolt and rivet looseness; timber integrity.
4	Liquid Penetrant	X			X		Crack or flaw detection in non-porous metals. Including Aluminum.
5	Ultrasonic Testing (Incl. Phased Array)	X		X	X	X	Non-homogenous investigation, delamination, surface crack and weld discontinuity detection. Including thickness reading to determine the extent of section loss. Steel welds and bridge pins volumetric tests.
6	Acoustic Emission	X		X	X	X	Crack, corrosion, weld defects and material embrittlement.
7	Magnetic Particle	X			X		Crack or flaw detection in ferrous metals.
8	Eddy Current	X			X		Crack or near surface defect detection in conductive metals. Can be performed through paint, but is limited on rough surfaces.
9	Radiography	X		X	X		Crack or flaw detection in ferrous metals. Internal defects, reinforcing layout in concrete.
10	Ground Penetrating Radar	X		X			Concrete deck voids, overlay thickness, and reinforcing steel location; soil/foundation engineering; and underwater profiling/scour location.
11	Infrared Thermography	X		X			Concrete deck delamination. Other material debondment (FRP wraps)
12	Impact Echo Testing	X		X			Internal concrete flaw detection.
13	Ultrasonic Pulse Velocity						Internal concrete flaw detection.
14	R-Meter Testing	X		X			Reinforcing steel concrete cover, location and size.
15	Half-Cell Testing	X		X			Corrosion of reinforcing steel in concrete.
16	Chloride Ion Testing		X	X			Corrosion of reinforcing steel in concrete.
17	Carbonation Testing		X	X			Depth of pH decrease and susceptibility of steel reinforcement to corrosion.
18	Penetration Hammer (Schmidt Hammer)	X		X			In-situ, relative surface hardness of concrete.
19	Windsor Probe		X	X			In-Situ, relative penetration resistance.
20	Resistance micro drill	X				X	Extent of decay in Timber
21	Stress Wave Timers	X				X	Extent of decay in Timber
22	Monitoring Systems	X		X	X	X	Measurement of loads and strains to calculate stresses in members.
23	Material Sampling		X	X	X	X	Various material properties and defects.
24	Unknown Foundation Investigation	X	X	X	X	X	Determination of foundation type or length of piles.
25	Hydrographic Surveys and side scanning sonar	X					Hydrographic surveys map a channel bottom and do not specifically test a structural component. However, locating areas of scour that can undermine substructure units allows the inspector to assess the integrity of the structure.

Figure 5.1.1-1: Summary of NDT & PDT Methods in Part 5.

5.1.2 NDE and PDE Inspector Qualifications

Nondestructive and partially destructive evaluation methods range from simple chain drags and timber coring to complex methods such as ultrasonic and Windsor Probe Testing. It is important that the person conducting the test, as well as the personnel interpreting the test data, be properly trained in the applied method. Additional qualifications should include both an understanding of the theory behind the test and practical experience. Inspection methods should be conducted in accordance with applicable American Society for Nondestructive Testing (ASNT) written practice in accordance with document (SNT-TC-1a) and written and approved procedures. Other testing methods should follow written procedures and sound engineering practices as found in American Society for Testing and Materials (ASTM) standards, and American Association of State Highway and Transportation Officials (AASHTO) specifications.

Refer to Part 1 of this Manual for the minimum standards for inspector qualification. Furthermore, Part 1 of this Manual discusses the requirements for submitting written practices and personnel certifications to WisDOT for review. Nationally recognized certifications in NDE are provided through ASNT and require a written practice in accordance with SNT-TC-1a. The SNT-TC-1a is a guideline for an employer based written practice that includes the qualification and education requirements to be certified to the employers written practice. The SNT-TC-1a allows for training requirements to be modified as allowed by the written practice, which is an agreement between the NDT provider and the customer.

Many tests are particular to bridges, such as thermography and ground penetrating radar testing of bridge decks, are not covered by ASNT certifications; however, these tests are covered by the ASTM standards and experience can be documented.

5.1.2.1 Specialists

NDE: NDE personnel shall be qualified in accordance with nationally recognized NDE personnel qualifications practice or standards such as ANSI/ANST-CP-189, SNT-TC-1A, MIL STD 410, NAS-410 or a similar document. The practice or standard used and the applicable revision shall be specified in the contractual agreement between the structure owner and the NDE inspector.

NDE Requirements: Consultants, contractors, and their subcontractors performing NDE magnetic particle testing (MT), liquid (dye) penetrant testing (PT) or ultrasonic testing (UT)] on bridges or miscellaneous structures as defined in the Wisconsin Structure Inspection Manual shall maintain their written practice and personnel certifications. And are required to produce them for review..

Consultants, contractors, and their subcontractors performing NDE (visual inspection) on bridges or miscellaneous structures, as defined in the Wisconsin Structure Inspection Manual, shall have taken and passed the NHI 80-hour course (Safety Inspection of In-service Bridges) or be certified as an American Welding Society Certified Welding Inspector (AWS/CWI) or submit their written practice and certifications documenting the equivalent training that qualifies their personnel to perform visual inspection on structures in the state of Wisconsin. The third option must be approved by the Wisconsin Department of Transportation's (WisDOT)

Statewide Inspection Program Manager, or their designee, for approval prior to performing any work.

5.1.3 Data Collection and Interpretation

Upon embarking on a nondestructive or partially destructive evaluation program, a plan should be developed which details the type(s) of testing to be performed, amount of data needed, test locations, criteria for data interpretation, and follow-up procedures for handling unanticipated test results. Many testing methods produce considerable test data. Data should be collected on the applicable forms, which include the location and test results. When possible, copies of all field data should be retained as part of the structure's official file.

Interpretation of nondestructive evaluation (NDE)/partially destructive evaluation (PDE) data should be performed by persons knowledgeable both in the test theory and in the analysis or evaluation of the structure being tested. For some tests, such as ultrasonic weld inspection, recognized criteria exists for evaluating the effects of any detected anomalies. However, for many other test methods, the NDT/PDT data must be evaluated based on each individual structure's behavior.

Most nondestructive programs detect and assist in the evaluation of flaws and discontinuities, as well as determining the strength or serviceability, by indirect methods. The tests typically indicate the existence, extent, and location of discontinuities. However, the influence of the discontinuity on the strength or serviceability of the structural component is often more difficult to determine. The validity of an NDE test or NDT depends on good engineering judgment based on experience, additional NDT, or fully destructive testing results. Note: NDE is nondestructive evaluation and may use many tools in the toolbox such as additional test of NDT. The information collected by NDE/PDE is typically raw data and the specialist must interpret the information to correlate it to a usable parameter. Also, certain techniques may provide false data under certain conditions; therefore, the specialist must be familiar with a technique and recognize the false readings. False positives from inexperience persons and poor procedures can result in over testing and repair of components that have no real problems. The understanding of how structures load paths, AASHTO fatigue details and the interaction of various loads can also play into the decision making process which often results in the extent of repairs and life expectance of a structure. Poor procedure and inexperience and non-qualified personnel can lead to false assurance and unanticipated failures. Likewise, the inspector should not recommend testing, or accept testing results, without being familiar with the technique. Adverse conditions and human factors such or rushed or incomplete NDE can result in missed flaws or discontinuities that could lead to failures. Critical members that cannot be tested due to bird droppings, inaccessibility, or hidden feature should be carefully considered for more extraordinary measure to ensure quality and integrity of the member in question. These efforts may include steam cleaning, sand blasting, paint removal, remote inspection methods, strain gages and finite element analysis. These used in addition to systematic and sound engineering practices and experienced personnel and diligent research may be necessary to ensure reasonable safety, and integrity.

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