Bridge Inspections: Types/Scope/Frequency

Standardizing the process in Ohio.

The Ohio Department of Transportation has developed a standard scope of work for the safety inspection of state bridges to be used as the basis for inspection agreements. This scope of work is intended to provide the framework to cover the types of bridge inspections and allow the user to define additional special requirements.

There are five general types of bridge inspections: initial, routine, damage, in-depth, and special inspections. The type of inspection is not dependent on the type of structure being inspected, the method of access used, or the inspection procedures followed. An inspection event, particularly for large, complex, or deficient structures, often requires that a variety of inspection types be performed, using a variety of methodologies. For example, a fracture critical member will routinely receive an in-depth inspection, while the remainder of the bridge may not. In another example, the underwater inspection of a particular structure may require that specific elements receive in-depth inspections, while other underwater elements may require only routine inspection.

Each bridge in Ohio is inspected at least once each calendar year with no bridge exceeding an 18-month interval. The report is reviewed and submitted within 90 days for state agencies and 180 days for local agencies from field inspection date. Under normal circumstances, the inspection is performed and submitted as close to the 12-month interval as possible.

All inspection must be uploaded into the bridge maintenance system (BMS) no later than March 15, for the previous year's inspections (i. e., 2006 bridge inspection cycle needs to be uploaded into the BMS database by March 15, 2007).

Initial Inspections. An initial inspection is the first inspection of a new or existing structure, as it becomes part of the bridge inventory. Additionally, reconstructed structures may also require an initial inspection to document modifications of the structure's type, size, or location. The initial inspection includes an analytical determination of load carrying capacity.

The initial inspection is to verify the safety of a bridge, in accordance with National Bridge Inventory Standards (NBIS) and department standards, before it is put into service. It also serves to provide required inventory information of the as-built structure type, size, and location for BMS (and the NBI) and to document its structural and functional conditions by:

- Providing all structure inventory and appraisal data required by federal regulations along with all other data required by department standards and the local owner.
- Determining baseline structural conditions and eliminate deficiencies recorded under previous structural assessments.
- Clearance envelopes (for features carried and those intersected) and bridge waterway openings are documented at this time.
- Identifying maintenance needs, including preventive maintenance activities.
- Noting the existence of elements or members requiring special attention, such as fractured critical members, fatigue-prone details, and underwater members.
- Verify construction/rehabilitation contracts.

Documents, including but not limited to photographs, drawings (design, as-built, and shop drawings), scour analysis, foundation information, hydrologic, and hydraulic data, are to be inserted into the bridge file. Selected construction records (e.g., pile driving records, field changes, etc.) can be useful in the future and should be included. Maintenance records for existing bridges should also be included.

Unexpected problems with a small number of newly constructed bridges have demonstrated that safety inspections may be needed even for new bridges to determine their initial and long-term safety. Uncompleted non-bridge maintenance items (e.g., roadway drainage, channel debris, etc.) have caused significant bridge damage in several incidences. The inspection cycle is needed for effective planning and programming of bridge maintenance activities, especially on-demand repairs and preventive maintenance items. In addition, new asset management analysis tools for bridges and other assets require high quality bridge condition and require that bridge data be collected at regular intervals to provide good decision-making tools for bridge owners.

The level of effort required to perform an initial inspection will vary according to the structure's type, size, design complexity, and location. An initial inspection is a close-up, hands-on inspection of all members of the structure to document the baseline conditions. Traffic control and special access equipment may be required.

Initial inspections are performed for each structure after construction is essentially complete and before the bridge is put into service (or returned to service for bridges that have had a major reconstruction). For department bridges, data entry into the BMS for initial inspections is made within 90 days of the date the bridge is put into service. For local bridges, 180 days for data entry allowed by NBIS is acceptable. Bridges open to traffic during construction operations are required to be inspected

ROUTINE INSPECTIONS. Routine inspections document the existing physical and functional conditions of the structure. All changes to required inventory items that have occurred since the previous inspection are also documented. The written report includes appropriate photographs and recommendations for major improvements, maintenance needs (preservation, preventive maintenance, or on-demand repairs), and follow- up inspections. Load capacity analyses are re-evaluated only if changes in structural conditions or pertinent site conditions have occurred since the previous analyses.

A routine inspection should satisfy the requirements of the NBIS and department standards. Routine inspections serve to document sufficient field observations/measurements and load ratings needed to:

- Determine the physical and functional condition of the structure.
- Identify changes from the previously recorded conditions.
- Determine the need for establishing or revising a weight restriction on the bridge.
- Determine improvement and maintenance needs.
- Ensure that the structure continues to satisfy present service and safety requirements.
- Identify and list existing problems.
- Identify and list concerns of future conditions.
- Identify any inventory changes from the previous inspection.

The level of scrutiny and effort required to perform a routine inspection will vary according to the structure's type, size, design complexity, existing conditions, and location.

Generally, every element in a bridge does not require a hands-on inspection during each routine inspection to provide an acceptable level of assurance of the bridge's ongoing safety. The difficulty is that the areas not needing close-up scrutiny can not always be absolutely determined until after the entire bridge has been inspected and non-critical areas identified. Accordingly, to provide a reasonable level of confidence in the safety of the bridge, knowledge of the structure and good engineering judgment are necessary when considering those portions that will not receive the close up scrutiny with each inspection.

Areas/elements that may be more difficult to access but that warrant hands-on inspection in each routine inspection, include, but are not limited to:

- Load carrying members in poor condition.
- Redundancy retrofit systems (e.g., catcher-beams) for fracture critical details (pin hangers, etc.)
- Critical sections of controlling members on posted bridges.
- Scour critical substructure units.
- End regions of steel girders or beams under deck joint.
- Cantilever portions of concrete piers or bents in fair or lesser condition.
- Ends of prestressed concrete beams at continuity diaphragms.
- Other areas determined by the program manager of the inspection to be potentially critical.
- All bearings.

No portion of a bridge should go without an in-depth inspection at least once every five years. The application of these inspection guidelines do not relieve the engineer in charge of the inspection from the responsibility to perform other in-depth inspection tasks and tests needed to ascertain the condition of the bridge and assure its safety.

Routine inspections are generally conducted from the deck, ground and water levels, ladders, and from permanent work platforms or walkways, if present. Inspection of underwater members of the substructure is generally limited to observations during periods of low flow and/or probing/sounding for evidence of local scour.

Routine inspections are regularly scheduled inspections. The interval for routine inspections should be reduced from the maximum 12 months when the engineer determines that the bridge conditions have deteriorated to the point where additional scrutiny is warranted to ensure public safety. The district bridge engineer must approve the scope of work and interval of all inspections.

IN-DEPTH INSPECTION. An in-depth inspection is a close-up, hands-on inspection of one or more members and a close visual of all members above or below the water level to identify any deficiency not readily detectable using routine inspection procedures. An in-depth inspection may be limited to certain elements, span group(s), or structural units of a structure, and need not involve the entire structure. Conversely, in-depth inspections may include all elements of a structure. In-depth inspections can be conducted alone or as part of a routine or other type of inspection.

In-depth inspections serve to collect and document data to a sufficient detail needed to ascertain the physical condition of a bridge. This hard-to-obtain data is more difficult to collect than data collected during a routine inspection.

In-depth inspections should be routinely scheduled for selected bridges based on their size, complexity, and condition. Large bridges (longer than 500 ft) represent large capital investments and warrant closer scrutiny to ensure that maintenance work is identified and completed in a timely manner. Large bridges tend to be more critical to local and area transportation because of the usual lack of suitable detours. For large or complex bridges, it may be more difficult to provide a complete snapshot of bridge conditions when access difficulties limit the scope of regular inspections.

The level of effort required to perform an in-depth inspection will vary according to the structure's type, size, design complexity, existing conditions, and location. Traffic control and special equipment, such as under-bridge cranes, rigging, or staging may be needed for in-depth inspections. Personnel with special skills such as divers and riggers may be required. Non-destructive field tests and/or material tests may be performed to fully ascertain the existence or extent of any deficiency. On small bridges, the in-depth inspection, if warranted, should include all critical elements of the structure.

For large or complex structures, these inspections may be scheduled separately for defined segments of the bridge or for designated groups of elements, connections, or details that can be efficiently addressed by the same or similar inspection techniques. If the latter option is chosen, each defined bridge segment and each designated group of elements, connections, or details should be clearly identified as a matter of record and should be assigned a frequency for re-inspection. The activities, procedures, and findings of in-depth inspections are completely and carefully documented—to an even greater extent than is necessary for initial and routine inspections. Stated differently, in-depth inspection reports are detailed documents unique to each structure that exceed the documentation of standard or routine inspection forms.

A structural analysis for load carrying capacity maybe required with an in-depth inspection to fully evaluate the effect of the more detailed scrutiny of the structure condition. An in-depth inspection can be scheduled in addition to a routine inspection, though generally at a longer interval, or it may be a follow-up to a previous inspection. An in-depth inspection that includes all elements of the structure will satisfy the requirements of the NBIS and take the place of the routine inspection for that cycle.

In-depth inspections do not reduce the level of scrutiny for routine inspections. Program mangers should schedule in-depth inspection based upon condition and importance. Major bridges should receive an in-depth inspection every five years.

DAMAGE INSPECTIONS. Damage inspections are performed following extreme weather-related events, earthquakes, vandalism, and vehicular/marine traffic crashes, as directed by the district bridge engineer. In many ways, a damage inspection is a special inspection that is necessitated by an extreme event. When major damage has occurred, the inspectors will need to evaluate fractured or failed members, determine the amount of section loss, take measurements for misalignment of members, and check for any loss of foundation support.

Damage inspections determine the nature, severity, and extent of structural damage following extreme weather-related events and vehicular and marine traffic collisions/accidents for use in designing needed repairs. A damage inspection determines the immediate need to place an emergency restriction on a bridge (e.g., weight restriction or closure) for vehicular traffic. If a bridge is closed to vehicular traffic, the need to close it to pedestrian traffic should also be determined.

The findings of a damage inspection may be used to re-coup the costs of inspection and needed repairs or reconstruction from involved parties or other governmental agencies. Accordingly, documentation of the inspection may be critical in these efforts. For department bridges, the extent of damage and estimated costs of repair should be reported to the district damage coordinator.

The amount of effort expended on this type of inspection will vary significantly depending upon the extent of the damage, the volume of traffic encountered, the location of the damage on the structure, and documentation needs. The scope of a damage inspection must be sufficient to determine the need for emergency load restrictions or closure of the bridge to traffic, and to estimate the effort necessary to accomplish repairs. The capability to make an on-site determination of the need to establish emergency load restrictions may be necessary.

For structures owned by the state, an emergency fund is available from the central office to fund the emergency repairs to damaged bridges. This emergency fund alleviates the districts from having to use district allocations to contract emergency repairs.

SPECIAL INSPECTIONS. Special inspections are scheduled by the bridge owner to examine bridges or portions of bridges with known or suspected deficiencies. Special inspections tend to focus on specific areas of a bridge where problems were previously reported or to investigate areas where problems are suspected.

Special inspections generally are not comprehensive enough to fulfill NBIS requirements for routine inspections. Special inspections can be structured to fulfill the need for interim inspections between the 12-month routine inspections. Special inspections are conducted until corrective actions can remove critical deficiencies.

Special inspections are used to monitor particular known or suspected critical deficiencies, fulfill the need for interim inspections (i.e., reduced inspection interval for posted bridges), and to investigate bridge conditions following a natural disaster or manmade emergency.

The level of effort required to perform a special inspection will vary according to the structure's type, size, design complexity, existing conditions, and type of deficiency being investigated.

The program manager defines the scope and frequency of the special inspections. The qualified inspector performing a special inspection should be carefully instructed regarding the nature of the known deficiency and its functional relationship to satisfactory bridge performance. Guidelines and procedures on what to observe and measure must be provided. A timely process to interpret the field results by a professional engineer is required.

The determination of an appropriate scope and frequency for a special inspection frequency should consider the nature, severity, and extent of the known deficiency, as well as age, traffic characteristics, public importance, and maintenance history. Special inspections are typically at intervals shorter than 12 months.

Combined Sewer System Inspections. Culvert and drainage structures that meet the definition of a bridge are considered a bridge culvert so they are inventoried and inspected. An interior visual inspection of the portion of the combined sewer defined as the bridge is required to have an interior visual inspection every five years. An annual inspection report is required for each year. These structures are typically considered confined space.

Large-span multi-plate culverts, including box culverts, arches, pipe-arches, and circular pipes are relatively flexible soil interaction structures and more susceptible to failure when they lose their original global cross-sectional geometry. The inspection of these multi-plate culverts is sufficiently detailed to detect and monitor deformations (e.g., bulging; non-uniformity of the arch soffit, longitudinally or transversely; misalignment of plates; tearing; etc.) that could lead to a partial or complete collapse of the structure. Culverts under shallow earth fill are especially vulnerable to such deformations.

Bridge inspectors monitor the integrity of the culvert's shape as the primary indicator of any structural distress. The inspection file contains sketches indicating the as-built geometry and subsequent measurements to monitor the structure's performance at a minimum of two cross-section locations. Paint marks on the culvert assist the inspectors to ensure measurements are taken at consistent locations. GE

Excerpted from the Ohio Department of Transportation Manual of Bridge Inspection.

Handheld Device "Sees" Damage in Concrete Bridges

Engineers at MIT have developed a new technique for detecting damage in concrete bridges and piers that could increase the safety of aging infrastructure by allowing easier, more frequent, onsite inspections that do not interfere with traffic or service.

The technique involves use of a hand-held radar device that can see through the fiberglass-polymer wrapping often used to strengthen aging concrete columns to detect damage behind the wrapping not visible to the naked eye. Such damage can occur on the concrete itself, or to areas where layers of the wrapping have come loose from one another or even de-bonded from the concrete.

The new noninvasive technique can be used onsite from a distance of more than 30 ft and requires no dismantling or obstruction of the infrastructure. It provides immediate, onsite feedback.

Called FAR-NDT (far-field airborne radar nondestructive testing), the technique could prove especially advantageous for bridges that span rivers or highways, which can prove inaccessible for other inspection techniques. The MIT researchers first reported the technique in the proceedings of the International Conference on Structural Faults and Repair held in Edinburgh, Scotland, last year.

"The use of radar for detecting hidden defects and deterioration behind covered surfaces offers great potential for wide-range use in assessing the safety of bridges and buildings that have been retrofitted with composite materials," said Professor Oral Buyukozturk of the Department of Civil and Environmental Engineering (CEE), who developed the technique with CEE graduate student Tzu-Yang Yu and Dennis Blejer of MIT Lincoln Laboratory, where prototype radar measurements were made.

Fiberglass-polymer jacketing—shiny, textured fabric in black or ivory often seen wrapped around concrete columns—is widely used to upgrade existing concrete structures so they can carry a greater load or sustain additional earthquake impact. The wrap is also commonly used to retrofit structures that are damaged or deteriorating from weather or other wear.

Techniques presently available for inspecting these fiberglass-polymer jacketing systems require the inspector to come in direct or close contact with the structure. Some actually require removal of a physical sample, which itself could create a safety issue. The advantage of the new technique is that it allows a rapid inspection from a distance and provides computerized visualization of the internal damages.

"This technique would allow the engineers to perform reliable, in-situ inspection for visualizing and characterizing hidden damages from distances without having to endanger the structure by taking specimens from it, and at the same time, without disturbing the traffic or service," said Yu, whose Ph.D. thesis will focus on this research. "The project is an excellent example of bridging fundamental science and engineering applications."

The researchers have demonstrated the validity and potential of the new technique through experiments and computer simulations by sending and receiving radar signals using a "horn" antenna to inspect bridge piers from distances of more than ten meters. In their experiments, a horn antenna transmits a radar signal to a fiber-wrapped concrete specimen, which reflects the signal back to the antenna. The collected data are then converted by an imaging algorithm into a visualization of the interior of the specimen, including any damage.

The researchers say that the concept has been validated by their initial experimental results using an existing prototype radar system and by computer simulations. Future development of appropriate portable radar equipment for onsite use is necessary before the system can be placed in widespread use by industry. The work is funded by the National Science Foundation.

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