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Publication of this paper sponsored by Committee on Structures Maintenance.

Considerations for Administering Underwater Contracts

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ABSTRACT

The objective of this study was to identify the considerations for administering an underwater inspection program to be conducted by contractors. Issues include identifying and assigning a priority to structures for periodic inspection, establishing inspection procedures, selecting a contractor, formatting the contract, and estimating contract costs.

National bridge inspection standards require that all bridges located on public roads be inspected at least once every 2 years. The inspections are to be conducted in accordance with the AASHTO standards stated in the Manual for Maintenance Inspection of Bridges (1). In general, highway and transportation departments nationwide comply with these standards; however, many states do not have a program for routinely conducting underwater inspections (2). The Virginia Department of Highways and Transportation is attempting to strengthen its underwater inspection program through the efficient use of contractors.

The objective of the research reported here was to identify those aspects of underwater inspections that are necessary for an efficiently administered underwater inspection program, and can be specifically stated in a contract.

Meetings and interviews were conducted with personnel responsible for bridge inspections in the Virginia Department of Highways and Transportation, other states and federal agencies, and with contractors. The issues identified for consideration in administering contracts for underwater inspections are discussed here in a general manner, and it is anticipated that they will be modified, specifically by traffic engineers, structural engineers, economists, and those experienced in bridge inspections.

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IDENTIFYING AND ASSIGNING A PRIORITY TO STRUCTURES FOR UNDERWATER INSPECTIONS

Based on information available on their maps, many states appear to have responsibility for more bridges with substructures underwater than can be inspected in a short time; therefore a system of assigning priorities to upgrade inspection programs to include structures underwater is needed. The system would not be used to decide what bridges would be inspected, but to determine the order in which all bridges would be inspected during a given time period. Some of the variables that appear to be essential to such a system are discussed.

Risk Assessment

The importance of risk assessment stems from the need to provide safety for the users of the structures. Although the safety of all structures is important, those that would pose the greatest risk to the public in the event of failure must be distinguished from those that present less risk. Probable risk to the public is evaluated from traffic volume. Assuming the worst case, such as bridge failure, the greater injury probably would be sustained by the users of bridges with high volumes of traffic. Therefore, if traffic volumes were the only element to be considered, these bridges are of more concern than those with low volumes.

Structural Data

Although little historical information exists for accuracy, inspection priority is assigned by considering the types and conditions of structural elements. The elements considered are construction materials, quality of construction, foundation type, structure age (or remaining life), and moveable versus stationary spans discussed next.

Construction Materials

Depending on the type of water in which the substructure rests, the priority of inspection is affected by the type of materials involved (concrete, wood, or steel). For example, wooden structures in salt water are vulnerable to borer attack, concrete is susceptible to leaching of chemicals in the soil at the mud line (such as high sulfur), and steel would be subject to oxidation.

Quality of Construction

Engineering judgment is essential in rating the quality of construction. If this cannot be determined from data recorded when the structure was built, information from inspections of the superstructure can be used.

Foundation Type

Pilings constructed on rock foundations are not as adversely affected by scour as are friction piles. Friction piles would be weighted higher in the priority ranking than bearing piles, especially when scour is likely.

Structure Age

A life expectancy of 50 years has been arbitrarily assigned to bridge structures; thus, older structures should receive a higher priority.

Movable Versus Stationary Spans

The added risk of damage by boat and ship traffic under movable spans indicates a need to assign them a higher priority than stationary spans. An added risk is the turbulence from propellers of large vessels, which may cause "necking," a form of deterioration in sections of a pier.

Environmental Factors

The environment in which a bridge is located affects the demand for inspection. Weather, velocity of water flow, and water chemistry are variables that should be considered.

Over a period of time, cycles of freezing and thawing temperatures could result in significant damage to a substructure. Bridges in areas of the state where water commonly freezes in the winter should be assigned a higher priority than those in areas where temperatures rarely drop below freezing.

A substructure is more adversely affected by a rapidly moving stream than by calm water. Problems are also more likely to occur in areas of frequent flooding. The substructure would be vulnerable to undercutting by high velocity flows, cracking from large debris moving rapidly in flood waters, and scour.

Substructures are more adversely affected by salt water than by fresh water. Because the probability of spalling, corrosion from electrolysis, and so on, is greater in salt water, the structures there should be assigned a higher priority.

Economic Considerations

In addition to the safety of the traveling public, the protection of capital investments is a high priority. The inspection of bridge substructures facilitates preventive maintenance involving relatively inexpensive rehabilitation procedures that include costs of replacing the structure, repair, and detour length, and costly reconstruction is avoided. Economic considerations include any losses incurred by the public resulting from a structure being out of service.

When deferred maintenance necessitates replacement, structures with a high replacement cost obviously would be assigned a higher priority for inspections than structures with a lower replacement cost.

The cost of repair is slightly different from replacement cost. Considering only underwater operations, the resources needed to repair or reconstruct a structure having a moderate replacement value could be more costly than those needed to repair a structure with a higher replacement value. For example, repairs to a two-lane stationary span over very deep water would be extremely expensive because of the requirements for highly trained personnel and special equipment. In contrast, where the substructure of a bridge carrying a multilane highway is partly in shallow water, repairs may be less costly. Consequently, the former situation justifies more frequent inspections to detect minor distress and prevent the development of major problems.

The length of the detour required is important in a case in which a bridge is out of service. If the bridge provides the only reasonable route of travel to a given location, then it would be weighted higher than if it were one of several in the area.

Structural Evaluation

The service and maintenance history of a structure is important in assessing the need for immediate inspection. In many cases there are no documented underwater inspection files for the structures, although information from inspections of the superstructures is available and can be used in determining priorities.

DEVELOPING INSPECTION PROCEDURES

Levels of Inspection

Levels of inspection are used by the U.S. Navy and most underwater contractors to generally define the work of an inspection.

• A Level I inspection is a basic inspection (a swim-by) and does not entail cleaning or detailed measurements. The objective is to gather data based on observations (visual, photographic, or videotaped). The Level I inspection should follow the as-built plans of the structure with the intention of detecting obvious major damage or deterioration due to overstress, corrosion, or extensive biological growth or attack. This level of inspection is intended to be part of an initial evaluation of the exterior surface of piers, pilings, footings, and so forth.

• A Level II inspection obtains more information than is provided by the Level I and may involve cleaning and simple measurements using calipers, measuring scales, and probes or ice picks to estimate the depth of cracks or other damage. At times, more sophisticated measurements are required at Level II. For example, if simple measurements indicate a potential problem, a few detailed measurements may help to confirm this indication.

• A Level III inspection is highly detailed. Nondestructive techniques (such as coring), material sampling, and in-place surface hardness testing may be required. Commonly, the Level III inspection will require cleaning preparatory to conducting tests, and obtaining photographic or video representations.

Contractor Tasks

The types of tasks to be performed by a contractor conducting an initial inspection and a follow-up inspection are described. More detailed inspection procedures are given in the North Carolina Department of Transportation Underwater Inspection General Operations Procedures and Safe Practice Manual, compiled by the Bridge Division of the North Carolina Department of Transportation (3).

Initial Inspection

Initial inspections are usually slated for bridges or groups of bridges that have documentation of previous inspections. A Level I inspection would be conducted to note any obvious defects such as extensive spalling or scour. (Follow-up inspections would be scheduled where necessary.) At this level of inspection, a group of structures could be quickly evaluated to establish baseline data.

Three areas of the structure should be observed in a swim-by inspection: (a) the area around the mean water level to detect damage from cycles of freezing and thawing or from boat collisions; (b) the areas from the mean water level down to the mud line, at every 10-ft interval and around the circumference of the pier; and (c) the area at the mud line. The data from a mud line inspection would include condition of footing, extent of scour, the amount of debris collected around the pier, the condition of underground cables, and, if appropriate, soil samples from the mud line for chemical analysis.

Follow-Up Inspections

Follow-up inspections will be either Level I or Level II, depending on the results of any previous inspections. The purpose of a Level II inspection would be to gain detailed data. Usually, this involves light cleaning with steel brushes or scrapers and photographic or video documentation. The use of a computer program would facilitate the evaluation of structures and the scheduling of future inspections.

When inspections indicate possibly serious damage, cleaning and testing may require use of a water blaster with water applied to the structure under pressures ranging from 6,000 to 15,000 psi. At 6,000 psi, the jet would clean marine growth, and pressures near 15,000 psi would reveal loose or damaged material. Pressures above 15,000 psi could cause damage to strong concrete. It is important that the contracting parties agree with and document pressures used.

Color video is desirable for inspections when damage is suspected or when an initial inspection has indicated potential damage, or for documentation for reference. The use of color video enables an engineer on the superstructure to observe conditions below the water. In many circumstances, a diver who becomes "task fixated" will see only what is directly in front and miss obvious details. With the aid of color video, an engineer on the surface can communicate with and guide a diver. The video film can be retained for analysis and documentation.

Sampling

Inspections are necessary to provide the data for making decisions that will protect the users of structures and an agency's capital investments. Inspecting the entire portion of the structure underwater would provide the most reliable data; however, because of limited resources, total inspections are not always possible. The problem is to develop a valid sampling model for inspections of bridge substructures underwater.

There is little literature from research on this subject and no valid sampling formula is available. The main difficulty in developing this formula is that of determining the required size of the sample population. In addition to the variables that relate to the structure, such as age, material, and construction quality, environmental factors that affect the structure must be considered. To determine that all the piers in a given structure are homogeneous enough to constitute a population, at least additional variables of scour, damage from collisions, and freeze-thaw damage must be considered.

The results of a literature search indicate that there is not enough information available to validly state that all piers in a given group are affected in a predictable manner. It is improbable that a population could be defined based on available data.

If sampling is unavoidable, the worst case approach is suggested based on the response to this question, for example: What number of elements in a given structure could be eliminated without the probability of the structure failing? Next, the remaining elements should be inspected.

USE OF A CONTRACTOR

Selecting a Contractor

The regulations governing the use of contractors are spelled out in the Virginia Department of Highways and Transportation's DPM 6.8 (4). Usually, all contracts more than $10,000 must be awarded by competitive sealed bids or by competitive negotiations. Contracts of an emergency nature and single-term contracts of less than $10,000 are exceptions. The important factor in issuing contracts is to ensure that those bidding are qualified to perform the task.

Competitive negotiations appear to be more advantageous than sealed bids for underwater work. Many times, the tasks to be performed can be specifically stated; however, the options available to perform these tasks are not always clear to the contracting agency. In negotiating a proposed contract, the guidance of a potential contractor may increase the quality of the inspection and benefit all parties.

The qualification of an underwater contractor is especially important because the work performed is out of sight. Several factors should be considered when attempting to prequalify potential contractors. The following factors are discussed based on information received from the Naval Facilities Engineering Command located at the Navy Yard in Washington, D.C., and several underwater contracting companies.

Contractor Experience

A contractor experienced in underwater inspections is able to assess existing structural damage and accurately predict potential damage from data obtained. This is especially important on Level I inspections, because the diver is the only one to observe the structure. The diver's ability to describe his observations to a large degree determines whether the engineer in charge of the inspection declares the structure sound or calls for a Level II inspection. Contractors whose primary activity is underwater inspections should be distinguished from those that engage only in underwater construction or salvage. The latter should not be eliminated, but should not be accepted solely on the basis of having performed underwater work.

Contracting firms that routinely conduct bridge inspections employ structural engineers and draftsmen, but subcontract to a diving firm for underwater inspections. Because most highway and transportation agencies have highly qualified structural engineers, for efficiency, they should work directly with the firms that perform the underwater operations.

Personnel Qualifications

In most cases, for their own benefit, contractors engage divers who they believe to be competent. The most important consideration is the diver's experience: the number of divers made, number of hours spent under water, type of training, type of work performed, and recency of work.

Available Equipment

The equipment to be used by the contractor should be stated and the availability of that equipment should be verified before the issuance of a contract. Attention to these details ensures that the contractor and his employees have experience with the equipment and that work will not be delayed because the equipment cannot be obtained.

Establishing the Content of Contracts

From the information gained in the research reported here, the following outline of considerations to be contained in an inspection contract has been developed. Although highway and transportation agencies have a standard contract form, these considerations can be incorporated with little modification.

General Requirements

The general requirements state the objectives of the project. For example, the requirement might be to establish the general condition of all bridge substructures from 2 ft above the water line to the mud line, or to inspect a given location for possible damage resulting from boat or ship collisions. Requirements may also specify the capabilities the contractor must possess to perform underwater inspections, assess damage and deterioration, recommend repair techniques, and estimate repair costs. In addition, the estimated maximum length of time for completion of the project may be stated.

Administrative Procedures

The usual information such as channels of communication, information-reporting schedule, and submittal of vouchers is usually contained in this section of a contract. Especially with underwater contracts, task-oriented conferences between contractors and engineers-in-charge are important. The objective and frequency of these conferences should be stated.

Although the contracting agency should not specify how diving operations will be carried out, it should make a general statement about expected safe-diving practices. For example, it could state that a thorough check of underwater conditions, as well as other conditions pertaining to the proposed work, will be made before all diving operations, and that all diving operations will be conducted in accordance with the best commercial safety standards.

General Criteria

This section contains a brief statement that the contractor is responsible for the quality of submittals, including editing, accuracy of figures, and reproduction.

Study and Analysis

The level of inspection required usually is not explicitly stated but is worded in the form of a guideline. The study and analysis section should include the extent to which the data gathered will be analyzed. In almost all underwater inspections, an analysis must be made by the contractor because in the initial swim-by divers must decide what is significant and what is not. However, repair and cost analyses may not be desired, and this should be stated.

Specifications for on-site reporting should be stated. Some type of daily log should be maintained. Information such as the locations of all observations showing elevations along each pier or pile, water depth referencing mean low water level, and the position of the pier or pile on the bridge should be recorded.

Report Format

The contents and the format of the inspection report are important because the report contains the data to be used in future studies and in scheduling follow-up inspections.

Estimating Costs of Contracts

The calculation of a reasonable estimate of the cost for inspecting a given facility is difficult because of the variables unique to each structure. However, based on cost estimates contained in contracts awarded by the Naval Facilities Engineering Command and discussions with railway agencies and contractors, a daily average manpower rate of about $500 a day can be estimated for one dive team. Variables associated with the size and location of the structure will obviously affect this average.

Cost items that routinely vary from structure to structure are those for overhead, travel or per diem, equipment rental, and transportation. Unexpected variables, such as the need for emergency services and poor weather conditions, may generate additional costs. The extent to which the contracting agency provides bidders with accurate information, such as that on water depth, will determine the accuracy of estimates included in the bids.

ACKNOWLEDGMENT

The research reported here was financed from Highway Planning and Research funds administered through the Federal Highway Administration, U.S. Department of Transportation.

The opinions, findings, and conclusions are those of the author and not necessarily those of the sponsoring agencies.

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Publication of this paper sponsored by Committee on Structures Maintenance.