INSPECTION STARTS AT DESIGN

Experienced bridge designers and inspectors Erin O'Malley and Jason Nauman outline how the most common and challenging of inspection headaches can be addressed at design stage

While designers help bridges come into the world, bridge inspectors are their long-term doctors. Performing regular check-ups, they ensure bridges are in relatively good health year after year and, if they are not, they prescribe treatment or refer them to a specialist.

Each of these roles plays a key part in the life of a bridge, but there are choices made by bridge designers which can make it easier, or harder, for inspectors to fulfil their roles. With responsibilities in both inspection and design, we have a unique perspective on how design elements can play a significant role in the efficiency and cost of long-term maintenance. We have worked on bridges where inspections are easier and some that are much more difficult. The difference almost universally comes down to one factor: access.

Close-up access is particularly important for inspecting bridges comprising non-redundant steel tension members which could cause a partial or complete collapse if they failed. US federal regulations require that these bridges are inspected within arm's length. As designers, we know many access challenges can be addressed upfront during design. As such, inspectors are often engaged by colleagues to assist in design reviews and to offer input on access solutions.

Every bridge is different, and there is an unending number of unique inspection challenges. Steel girders can be placed too close together, requiring extra time and care to navigate equipment between them. A catwalk may be available, but only on one side of a bridge. Adjacent structures may be so close that they impede inspection equipment. Bird spikes, netting or cladding added after completion can obscure an inspector's view or prevent access.

Nevertheless, the issues we see fall into a few common categories, the first being exterior access. The inspection industry has developed a wide range of solutions for reaching all parts of bridges, but often we run into situations where it is very difficult to reach a location we need to. Some structure types – such as a through-truss or through-arch – can make it challenging to fit an inspection boom between structural members for deployment under the bridge. Steep cross-slopes can create challenges when positioning vehicles to look over the side, as can working around fencing for under-bridge inspection vehicles (UBIVs). In one case, we had to work with a transport agency to have a fence replaced with a gate so that the boom arm of a UBIV could reach over the the bridge edge.

The design solution here is to consider the means of access that is necessary to satisfy state and federal inspection regulations for the structure type being designed, paying particular attention to structure geometry/configuration and attachments such as fencing, signs, lights and utilities. Where unavoidable conflicts are anticipated, solutions such as a removable fence or inspection handrails, platforms or catwalks should be proposed ahead of time. The cost of these proactive solutions can be contrasted with the cost of a more complex means of access that could be necessary for the life of the structure.

The next challenge is interior access. When interior access is required for inspection and maintenance activities, difficulties often come down to the size and location of openings. A steel box cap may be only 60-90cm wide to begin with, so the openings in the stiffeners may be only 30-45cm wide. Squeezing through these can be tricky, but it is critical to get past the stiffeners because the cap could be 18-21m long with only one access hatch at the end; it cannot be inspected by just leaning halfway into the opening. Furthermore, a ladder may be needed to reach the top of the tallest webs inside a large segmental box bridge, but the access hatch might be sized for only one person, or it might be so near the end of the next span that it prevents long objects from being threaded through.

The design solution for interior access is to maintain a minimum access width for openings and, while any existing state regulations take precedence, we would suggest at least 53cm depending on the height and location of the opening. Where this isn't possible, an alternate means of access such as multiple access hatches should be provided if continuous access of an interior space is obstructed. The height and vertical position of openings in stiffeners and diaphragms should also be considered for inspectors and maintenance personnel who need to climb through the structure. The equipment needed should also be anticipated. If rope access inspections are expected, concrete anchors could be added.

Size and weight restrictions are another significant issue, as inspection equipment such as boom lifts or UBIVs can be heavy. If they are to be relied upon for inspections throughout the life of the structure, it is important to ensure the structure is designed to safely handle their weight. This is critical for shared-use paths attached to vehicular bridges where these sections may not be designed for such weight. The walkways could be too narrow for an inspection vehicle, or they may include meandering paths, planters and benches that are difficult to drive around. The paths may also increase the overall width of the structure to the point of pushing it beyond the reach of a standard UBIV deployed from one side of the bridge. The design solution of ensuring that the structure can accommodate the size and weight of inspection equipment may also involve using an auto-turn software program to confirm the equipment can be manoeuvred as well as driven on/off the bridge.

Maintenance is another major challenge. Whatever the condition of a bridge at completion, a bridge that is not well maintained will be more challenging to inspect. For example, hatches become rusted shut, catwalks and ladders become unsafe, and vegetation can obscure or block access.

All of these issues can be addressed at design stage by considering the types of maintenance activities that need to occur during the structure's lifetime. Choosing resilient, long-lasting materials and developing details that require less maintenance is crucial. So is thinking about potential moisture/debris that can build up on structural elements, especially on steel structures where such an action can lead to pack rust and laminar corrosion, impeding visual inspection. Of course, all the difficulties outlined above are arguably surmountable. A stuck hatch can be retrofitted or rope access inspection can replace use of a truck, but each of these adds time and cost to an inspection, potentially impacting traffic.

Involving an inspection expert early on during the design process and developing a maintenance inspection manual should be best practice, particularly when dealing with complex or high-profile structures. The industry is moving in the right direction and this is particularly true of large signature bridges, where designers are putting significant thought into future inspection needs. Recently, during their work on a large tied-arch bridge, our designers knew that future inspections would be completed using rope access. Knowing the arches would also have architectural lighting, they consulted inspectors on how future inspections could be accomplished without damaging the lights.

Accounting for size and weight of inspection equipment is important in design

As bridges are replaced worldwide and new ones constructed, planning for future inspections is a key part of ensuring that these structures can be maintained and managed well for decades to come

Erin O'Malley is industrial rope access programme leader for bridges and structures at HDR and Jason Nauman is AZ/NM bridges and structures business class manager, also at HDR